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PRELIMINARY INVESTIGATIONS OF THE PROBABLE DIAMETERS, MASSES AND DENSITIES OF THOSE SATELLITES WHICH HAVE MEASURABLE DISCS.*

T. J. J. SEE.

The study of the diameters of the satellites of the principal planets is beset by many difficulties. In the entire solar system only seven out of the twenty-one satellites are known to present images differing sensibly from the spurious discs offered by the fixed stars. Moreover, the discs presented by these objects are very small, and as seen in the telescopes are greatly disturbed by the stream-like motion of the atmosphere. The unsteadiness of the image increases the difficulty of exact measurement, and the same causes which produce a tremor of the whole image render its limbs broken and indistinct. The result is that the image is both unsteady, and poorly defined at the limbs. The measurement of such an object is therefore an operation of extreme nicety. At best it is a matter of approximation, depending on the skill and diligence of the observer, and his practical ability to eliminate these disturbing causes.

For some time the writer of these lines has been occupied with investigations of the diameters of the principal measurable satellites. The results so far obtained are preliminary, but it is thought that sufficient progress has been made in the study of the problem, to give an indication of the probable outcome.

It is well known that the satellites of Mars, Uranus and Neptune have no measurable diameters in any telescope, and the values deduced for these bodies have been based on photometric measures, with certain assumed albedoes. Where the diameter and mass of the satellite is unknown, it may perhaps be assumed that the density is somewhere in the region covered by the densities of the known bodies, which range from 0.68, in the case of Saturn, to 5.5 in the case of the Earth.

It appears worth while to recall in this connection the densities

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of the principal planets, so far as known. In a paper on the Mass of Mercury recently communicated to the *Astronomische Nachrichten* (not yet published), it is shown that the densities of the four inner planets and of the Moon are as follows:

Planet.	Density.	Planet.	Density.
Mercury	3.00	Jupiter	1.35
Venus	5.14	Saturn	0.68
Earth	5.50	Uranus	1.69
Moon	3.34	Neptune	2.29
Mars	4.00		

The densities of the outer planets deduced from my recent investigations are also added in the last column. These figures, especially in the case of Neptune and Uranus, depart considerably from those heretofore accepted, but I believe them to be much closer to the truth than the old values.

The four inner planets and the Moon are solid, the four great planets fluid or quasi-liquid, bodies. The average density of the inner planets and of the Moon is 4.25. But it may be observed that among the inner group the smaller bodies are less dense than the larger ones, probably because the material of which they are composed is less compressed by the action of gravity.

The great fluid or quasi-fluid planets have an average density of 1.50. As the satellites are very small, and therefore in most cases presumably solid, it may be assumed that their densities resemble those of the inner planets, except so far as the densities are diminished by the small gravitating power of the masses. In this respect the densities would tend to approach those of the outer planets, but from a different cause. The low density of the outer planets is due largely to their gaseous condition, incident to an early stage of development; while that of the satellites, if confirmed, should be attributed mainly to their small mass and slight gravitating power.

For the fourteen satellites which have no measurable discs, and whose masses are unknown, it would be natural to assume the densities to lie between 1.50 and 4.25, with a probability in favor of a value of about 2.50. Those satellites which have measurable discs and known masses afford us some valuable hints on this point. The following determinations (Table A) of the diameters of Jupiter's satellites have been published.

TABLE A.

Authority.	Source.	Epoch.	Sat. I.	Sat. II.	Sat. III.	Sat. IV.	Remarks.
			″	″	″	″	
J. D. Cassini	Houzeau, V. M. p. 679	1693	1.92	1.97	2.06	1.96	From time of obscur. in shad. of plan.
Schroeter	" " "	1798	1.16	0.95	1.73	1.18	From time of entrance on disc.
Schroeter & Harding	A. N. 97 (Struve)	——	1.063	0.870	1.543	1.074	From contacts with disc, entrance and exit from transits.
W. Struve	A. N. 97; Mem. R. A. S. III. 301	1829	1.015	0.911	1.488	1.273	8n, power 600. 9.9 inch Dorpat Refr.
Secchi	A. N. 1017	1856	0.985	1.054	1.609	1.496	I on 1n; II on 1n; III on 6n; IV on 2n. Finds detail on III; susp. rapid rôt.
Mädler	Dorp. Beob. XV, II. 49	1863	1.200	1.132	1.519	1.300	I on 7 n; II on 10 n; III on 11 n; IV on 11 n.
Engelmann	Hell. Verh., Leip. 1871, p. 36	1871	1.081	0.910	1.537	1.282	4n, 8-inch refr., power 660.
Pickering	Harv. An. XI, II, ch. 8, 1879	1879	0.924	0.866	1.096	0.651	Determined photometrically 36-inch refr.
Hough	Chi. Astr. Soc. Rep. 1881	1881	1.114	0.981	1.778	1.457	
Barnard	M. N. LV. 382	1894	1.048	0.874	1.521	1.430	I on 8n; II on 8n; III on 10n; IV on 9n.
Michelson	Pub. A. S. P. 1891, p. 271	1891	1.02	0.94	1.37	1.31	4n, Lick 36-inch refr., Lick Observatory.
Burnham	" " " "	1891	1.11	1.00	1.78	1.61	1n, 36-inch refr., by interfer. methods.
Lewis & Dyson	M. N. LV. 479	1895	1.084	0.959	1.454	1.350	10 n, Grw. 28-in. refr., power 670, 450.
W. H. Pickering	Ann. Lowell Obs. II	1892	1.05	0.94	1.42	——	13-inch refractor at Arequipa, Peru.
Douglass	A. N. 3500	1897	0.81	0.64	1.34	1.26	24-inch refr. at Flagstaff, Ariz., 10n.
Hamy	Bull. astronomique 1899.273	1899	0.94	0.84	1.23	1.26	Michelson's interf. meth., Eq. coudé, 7n.
See	A. N. 3670	1900	0.67	0.62	1.36	1.28	18n with 26-inch refr. at Washington.

A study of the best standard measures of this table, made in the light of my own recent observations of these bodies, and of the constants of irradiation, leads to the following probable absolute diameters:

TABLE B.

Satellite.	Obs.	Cor. for Irrad.	km.
	″	″	
Satellite I.	1.08	0.88	3318
Satellite II.	0.96	0.76	2865
Satellite III.	1.58	1.28	4826
Satellite IV.	1.44	1.24	4675

The masses of the satellites, in units of that of Jupiter, have been determined by several astronomers, from the effects of their mutual perturbations upon the elements of the orbits.

The profound investigations published by Laplace in the *Mécanique Céleste*, L. IV. VIII., lie at the basis of these researches. The masses adopted by Laplace depend on Delambre's discussion of numerous eclipses and transits, and are evidently much the best available until quite recently. The following table gives the chief material of interest:

TABLE C.

Authority.	Satellite.	Mass.	Source.
Laplace	I.	0.0000173281	*Mécanique Céleste*, Livre
	II.	0.0000232355	viii. ch. ix. 27.
	III.	0.0000884972	
	IV.	0.0000426591	
Demoiseau	I.	0.0000168770	Tables Ecliptiques des
	II.	0.0000232270	Satellites de Jupiter.
	III.	0.0000884370	
	IV.	0.0000424751	
Adams	I.	0.0000283113	Collected Scientific Papers,
	II.	0.0000232355	Vol. 11. p. 191.
	III.	0.0000812453	
	IV.	0.0000214880	

With the diameters adopted in (B) and the masses found by Adams in 1875, (cf. Collected Scientific Papers, vol. 11, p. 191), the densities come out as follows:

	Density (water = 1).	
Satellite I.	2.80	(D)
Satellite II.	3.57	
Satellite III.	2.62	
Satellite IV.	0.76	

These simple figures are of very considerable interest; while not claiming great accuracy, they probably are not subject to enormous uncertainty. In the first place, the masses depend on Laplace's celebrated analysis of the mutual perturbations. The three inner satellites especially, on account of the great inequality

effecting their motions, afford excellent criteria for determining their masses. The numerical co-efficients of the analysis depend on Delambre's discussion of a vast number of eclipses and transits, and are sufficiently accurate to have served as the basis of all the tables heretofore published. It is not to be supposed, however, that a refined analysis of modern observations would not lead to sensible improvements. In the second place, the accepted diameters are deduced from the best micrometer observations, and corrected for irradiation. The mean of the measures of the best observers should approximate the truth very closely, and unless the irradiation applied is sensibly erroneous, the absolute diameters above adopted should lead to a fair approximation to the true density. The figures here obtained are based upon what I believe to be the best micrometer measures for the diameters, and the improved masses employed by Adams.

It is noticeable that the Satellites I., II. and III. have densities comparable to those of the Moon and of Mercury; while satellite IV. is very rare, and in constitution resembles the planet Saturn. The second, according to these values, is the most dense. I am convinced by numerous observations that it is the smallest of all these bodies; accordingly, unless the masses assigned are sensibly erroneous, it is also the most dense, which is a little remarkable.

If we examine the state of our knowledge of the satellites of Saturn, we shall find five determinations of the diameter of Titan:

Authority.	Epoch.	Source.	Diameter.	Remarks.
			″	
W. Struve	1826	A. N. 97, p. 14	"About ¾"	"Appears as a disc," W. Struve.
Mädler	1860-1	Dorp. Beob. XV. II. 51	0.753	Mean of 2 nights, 0″.799, 0″.707.
Barnard	1894	M. N. LV. 378	0.558 ± 0.031	Lick 36-in., 5 nights.
Lewis & Dyson	1895	M. N. LVI. 16	0.950	Greenwich 28-inch; mean of 3*n*, 0″.990, 0″.828, 1″.028.
See	1900	A. N. 3686	0.487	Mean of 12 measures, 26-in. Refr.

Among the eight satellites of Saturn, Titan and Japetus present measurable discs; and thus far Titan alone admits of a determination of mass. This has been carried out by Hill (*A. J.* 176), who finds a mass of $\frac{1}{4714}$, from the perturbations of Hyperion; and by H. Struve (*Beob. der Saturntrabanten*, Abth. I.), who derives a value of $\frac{1}{4678 \pm 350}$ from the secular perturbations of Japetus. These determinations were made independently

about the same time, and are entitled to about equal weight. Using for Titan a mass of $\frac{1}{4700}$, and a diameter of 0″.70, as corrected for irradiation, the resulting density is 2.03, which seems admissible. On the other hand a diameter of 0″.52, such as is indicated by the measures of Barnard and those made by the writer during the opposition of 1900, would lead to a density of 5.6, greater than that of the Earth, and therefore improbable. Moreover, careful measures during the present opposition indicate decidedly that the diameter is probably about 0″.90, somewhat greater than that obtained last year. The mass of Japetus is unknown, and the diameter very small (probably about 0″.3), so that no determination of its density can be made. The result of this inquiry, so far as it may be considered decisive, indicates that the average density (2.36) of the satellites is about the same as that of the matter which composes the crust of the Earth.

WASHINGTON, D. C.,
1901, Aug. 16.

UPS AND DOWNS, AND HERE AND THERE OF AN ASTRONOMER.

LEWIS SWIFT, F. R. A. S.

FOR POPULAR ASTRONOMY.

My astronomical work in California being ended, I find myself again in Marathon, near where I first commenced the study of astronomy without a teacher, and on a very small scale, armed only with a determination to succeed. My arrival brings forcibly to mind the early resolve to succeed in spite of obstacles which I clearly saw would certainly arise, and must be surmounted.

It has occurred to me that perhaps a brief recital of my failures and successes, and the disadvantages under which I for many years labored, may not be wholly devoid of interest and profit to the astronomical student, as an example of what perseverance can do.

Some 45 years ago, I bought of Mr. Spencer, the celebrated microscope maker, a 3-inch achromatic object glass, damaged by a streak in one of the lenses, for five dollars. I made a tube for it, and an eyepiece, and commenced the examination of the heavens, this being my first view of celestial objects through a telescope. The pleasure however was of short duration, as a careless servant girl broke the crown lens. I then ordered of Henry Fitz, of New

York, a 4½-inch comet seeker. For that I built a small Observatory with a conical revolving dome covered with canvas, five miles from this village. In a year or two I moved to Marathon, but finding no good place to use it, I cut a hole through the gable of my barn to crawl through, and built a platform on which to observe. My first stroke of luck was the discovery of the famous comet of 1862 III, having a period of 122 or 123 years and whose elements are almost identical with the August 10th star shower.

My astronomical library consisted only of Burritt's atlas and book, by the aid of which I began to learn the names of the brighter stars and boundaries of the constellations. In 1872 I moved to Rochester, my observing place being in a dark alley, lying in the dirt in the summer, and snow in winter.

My first mishap occurred one evening when a lady and gentleman came to look through the telescope, and to show them the object I desired I was obliged to move it a short distance; in doing so I stumbled over a little mound of dirt some children had made and with the telescope fell to the ground. The glass was not injured, but the object end of the tube was made very slightly elliptical. Curiously enough when the weather was mild, I had no trouble to screw the object glass cell into it, but never could when the weather was of zero temperature. For the result one cold night see further on.

One dark night one of the proprietors of the cider mill happened to go into his back yard, a thing he seldom did, and leaning against the fence saw what he said was either a black bear, or a drunkard, or the devil wallowing in the dirt. If it was the latter gentleman he desired to make his acquaintance. Softly approaching the strange object it proved to be a man looking at the sky with a telescope! Finding I was nightly engaged in comet seeking, said the flat roof of the cider mill would be a good place for me, and that I could use it if I desired. The next day I transported my telescope to it. Its flat pebbled roof was large, thus cutting off the near by street lights. It was a half mile from my residence and to get to the top it was necessary to climb three ladders and what was worse, to walk some 100 feet on a slanting roof, which in the early morning hours was often covered with frost, necessitating walking on hands and knees.

There during five years, being a hardware merchant by day and a comet seeker by night, I discovered six comets, besides a bitter experience. On a very cold night, as before said, I was unable to screw the objective into the tube, so was obliged to let the screw

threads cross. Shaking it strongly it was pronounced safe. About midnight, frost condensing on the glass, I attached the dew tube, which on removing at daylight somehow detached the objective, and falling on the pebbled roof broke the flint lens into a thousand fragments, but did no damage to the crown, which I sent to the Clarks to repair. Stumbling over the pile of dirt in the alley cost me one hundred dollars.

For fear of fire, I always carried home in a basket the glass and the eye pieces, being often stopped by policemen taking me to be a thief!

Dr. Ralph Copeland, Astronomer Royal of Scotland, on his return from his transit of Venus expedition, visited me, and after the first salutation was over desired me to take him to the cider mill. Arriving, the proprietor who saw me in the alley, said: "No wonder he can find comets in such a spiritual place!" About these days I was introduced to a Mr. H. H. Warner who handed me a twenty dollar bill and said, "if you want any more come over to the office and get it." It appeared a strange reception from a perfect stranger. Afterwards meeting him he said: "If the people of Rochester will buy you a 16-inch telescope I will build a nice Observatory and dwelling attached." Drawing up a subscription paper, I made a desperate effort to raise the sum needed. Enough was soon raised to pay for the telescope, spectroscope and sidereal clock, amounting to twelve thousand five hundred dollars.

True to his verbal promise he began its construction of white sandstone brought forty miles. The attached residence was finished off in hard rare woods, which, including the site, must have cost him $40,000. When about half completed he handed me his check for $500, saying, "put this under the carpet, it will come handy when you get in the Observatory." I also received from him $400 as prizes for the discovery of comets and a beautiful gold watch.

While director of the Warner Observatory, I discovered several comets and nine hundred nebulæ. Afterwards the generous man failed and I was obliged to abandon the beautiful Observatory, which cast a gloom over the city as well as me. In 1894 Professor T. S. C. Lowe, of Pasadena, Cal., was engaged in building an electric railway up the San Gabriel mountains, and desired the astronomical equipment transported to an Observatory. He promised to build 3700 feet above the Pacific Ocean which was plainly visible. He desired it as an additional attraction. The Observatory was completed, the instruments mounted, and while

its director, I discovered two more comets and 340 more nebulæ. My son Edward also discovered a comet with the 16-inch, the only one ever found with it. While there my wife died and I brought her remains here and buried her beside a former wife. Shortly after my return two men broke into my sleeping room, and seeing me said, "the hotel is on fire." Seizing my clothes and medals rushed to a place of safety but lost many articles and papers of value. Previous to this I saw with my naked eye a comet within half a degree of the Sun's upper limb at sunset. Seizing an opera-glass I was astonished to see another and fainter, about a half degree north of it and some distance from the Sun. Both were afterwards seen by the manager and several employees through three different opera-glasses. The sky was red like our eastern Indian summer, the Sun being seen without discomfort. They, especially the brighter, must have been very bright to have been seen through such a sky by daylight. I failed to find them again with the comet-seeker.

To my regret Professor Lowe also failed, which again brought my work to an end. Then my good eye failed, which was a great disappointment. I had done all my telescopic work with it. This compelled me to dispose of my entire equipment, except the comet seeker, which my children forbade me to sell. The instruments are still with Lowe Observatory under the directorship of Professor E. L. Larkin, who is making valuable discoveries, particularly with the spectroscope, the mountain atmosphere being especially adapted for it.

Those who have followed me through this checkered digest will see that what I have accomplished under discouraging difficulties, has been the offspring of perseverance, the details of which I have writen for the amateur to follow where unfathomable mysteries in the heavens still await him to solve, only hoping that he can say as do I, that sometimes

"Though bitter has been the bud,
Yet sweet has been the flower."

THE LIGHT CURVE OF THE NEW STAR IN PERSEUS.

H. C. WILSON.

[CONTINUED FROM PAGE 454].

In the collection of the observations we have attempted to gather and arrange in chronological order all of the observations which will be of value in determining the light curve and to give such of the details of the comparisons as will enable anyone to

verify the reductions or to reduce the observations to any other system of magnitudes. It has been necessary to condense the matter in some cases and to change the designation of the stars in others, but so far as possible consistent with a uniform plan we have given the observations in the form originally published. The second column gives the Greenwich mean time to the nearest tenth of an hour, the third the observer's name, the fourth the separate comparisons or the names of the comparison stars, or the word photometer, signifying that the observation was made with the aid of a photometer. The fifth column gives the magnitude of the new star as deduced by the observer, while the sixth gives that resulting from our own reductions. The last column together with the footnotes gives in brief the remarks published concerning the color of the star. The following abbreviations are used:

W = white	WY = whitish yellow
BW = bluish white	O = orange
CW = clear white	LO = light orange
OW = orange white	DO = deep orange
YW = yellowish white	WO = whitish orange
B = bluish	R = red
LB = light blue	BR = bright red
G = green	DR = deep red
Y = yellow	CR = carmine red
FY = full yellow	OR = orange red
OY = orange yellow	VR = very red
PY = pale yellow	YR = yellowish red

It has not been thought best to burden the columns with the multitude of remarks concerning the state of the atmosphere, except in a very few cases where it seems evident that the observations were seriously affected.

In the fourth column under "Comparisons" when the original comparisons are given, they are usually in a form similar to the following:

α Leonis 4 N; N 2 α Gem.; N 2 α,

which signifies that α Leonis was four steps brighter than the nova, and that the nova was two steps brighter than α Geminorum and α Persei. In some cases, especially where there were only two comparisons the data have been shortened by leaving out one of the N's and the semicolon, so that the example quoted would read:

α Leonis 4 N 2 α Gem.; N 2 α.

Where the Greek letters are given with no constellation name following them, the star is understood to be one of the Perseus group. Numbers in parentheses as (71), (72), etc., are the numbers of the stars in the list of comparison stars given in this article.

A few observers have given several stars on each night with the number of steps between them in succession, as for example

$$\kappa\,1\,\nu\,1\,\mathrm{N}\,1\,\iota\,1\,\theta\,1\,\sigma\,3\,\psi = \omega,$$

which is a very concise and accurate method, and makes it possible very largely to eliminate the errors resulting from the use of variable comparison stars and to check the constancy or variability of the step-value of the observer. It seems a pity that more did not use this method in the study of Nova Persei.

A few others did not attempt to estimate the difference of brightness in steps, but to locate the brightness of the the new star proportionately between two comparison stars. For example

$$\nu\,1\,\mathrm{N}\,3\,l$$

by this method signifies that the new star was one fourth of the way from ν to l Persei in brightness.

In the reduction of the observations it has seemed best to make each night's observation by each observer independent of all the others. In a few cases the value of a step appears to have been reasonably constant, but for most of the observers, the writer included, it was a variable quantity depending upon the clearness of the air, the different positions of the pairs of stars, and probably also upon the colors of the comparison stars.

When at least three different comparison stars were employed, the observations were reduced by the method of least squares. Equations of the form

$$x + sy = m$$

were formed from each comparison, x being the unknown magnitude of the nova y the value of one step, s the number of steps from the nova to the comparison star, and m the adopted magnitude of the comparison star. For the reduction of smaller numbers of comparisons and for checks upon all the reductions the average value of y was determined where possible for each observer. The different methods of reduction give nearly identical results in most instances, the difference seldom exceeding 0.1 magnitude.

The resulting magnitudes were platted on squared paper to such a scale that a difference of 1 magnitude = 28 millimeters and 24 hours = 34 millimeters. In the reproduction the scale has been reduced to a little less than one-half of the original. The photometric observations are represented by full black circles, the observations by steps which we were able to verify or reduce to the adopted system by open circles, and those which could not be verified by crosses. The observations for which no time was stated have been omitted from the plat.

COLLECTION OF OBSERVATIONS OF NOVA PERSEI.

Date 1901.	Gr. M. T.	Observer.	Comparisons.	Magnitude. Obs'r.	Revised.	Color
Feb.	h					
21	5.9	Borisiak		1.5		
	6-7	Schwab	Compared Algol with $o, \xi, \nu, \kappa, \rho$ and 16 Persei but did not see Nova.	<5.0		
	8.0	Plassmann	Observing Algol, did not see Nova.	<3.0		
	14.7	Anderson		2.7		B W
22	5.6	Sviatsky		1.3		PY
	6.6	Schwab		1.5		W
	7.0	Copeland	$0.3^m >$ α Tauri		0.7	
	8.1	Sviatsky		0.5		P
	8.2	Copeland	N = Procyon		0.5	*
	9.8	Hartwig	N 3 $(0.2^m) >$ β Gemin.		1.0	
	11.6	Hartwig	N = Pollux		1.2	
	?	Marckwick		0.5 or 0.75		B W
	12.5	Micou	Capella 2 N; Rigel 1 N 1 Procyon	0.5	0.41	
	14.0	Wendell	Photometer	0.35		
	17.4	Wendell	Photometer	0.39		
23	4.5	Scheller	> α Persei in Meridian Circle			
	4.6	Sviatsky		0.2		PY
	4.6	Kvasnikoff	> α Persei			
	5.5	Scheller	> α Aurigæ to naked eye		>0.22	
	5.5	Köhl	> Capella		<0.22	
	5.7	Baliasny		0.3		
	6.3	Nijland	= Capella		0.22	
	?	Hartwig	= Capella		0.22	
	8.2	Halm, Clark	$0.2^m >$ Capella		0.0	
	8.2	Plassmann	= Capella		0.22	
	8.6	Clemens	Photometer : N = Capella $- 0.17^m$	0.10	0.05	
	8.8	Gautier	= or < Capella		0.2	
	8.9	Dolanski	= Vega		0.13	
	9.2	Müller, Kempf	Photometer	0.24	— 0.06	W
	9.0	Miclaucic		0.2		
	9.6	Graff	> Capella		>0.22	C W
	10.6	Gautier	Between Capella and Procyon		0.3	
	11.5	Kreutz	> Capella		>0.22	
	12.5	Micou	N 1 Capella	0.1	0.14	
	13.1	Graff	> α Lyræ > α Aurigæ		0.1	*
	14.	Olivier	$0.2^m <$ α Lyræ	0.3	0.4	†
		Harvard	> α Aurigæ	0.0		‡
	16.5	Kohl	Brighter than Vega		>0.13	
	18	Brooks	> Capella		>0.22	¶
24	5	Borisiak		0.1		
	4	Seagrave	Capella 2 N		0.4	
	5.8	Kreutz	= : Capella		0.2:	
	7	Messow	α Aur. > N > α Can. Min.		0.3	
	7	Nijland	Fainter than Capella		<0.22	
		Gautier	< Capella			W‖

* Color of Procyon. † Color of α Lyræ. ‡ Bluer than α Lyræ. ¶ Color of Capella. ‖ White without a trace of blue.

Date 1901.	Gr. M. T.	Observer.	Comparisons.	Magnitude. Obs'r.	Revised.	Color
Feb.	h					
24	9	Hohl		0.7		
	9.8	Messow	< α Aurigæ		<0.22	
	10.7	Yendell	N 1-2 Capella		0.07	Y
	11.2	Yendell	N 0.25^m > Capella; 0^m.25 > Rigel		0.03	
	11.7	Clemens	Photometer: N = Capella + 0.38	0.65	0.60	
	12-14	Olivier	0.1^m < α Lyræ		0.32	*
	12	Seagrave	Capella 3 N		0.5	
	12.4	Wendell	Photometer	0.59		
	13	Seagrave	Capella 3½N 5 Pollux		0.6	
	13	Micou	N = Capella	0.2	0.22	
	?	Brooks	= or < Capella			
	14.5	Archenhold	Capella 10 N 10 β Aurigæ		1.13	
	16.2	Matthiessen	½^m < Capella; ½^m > α Persei		1.0	
	16.6	Moller	= : Capella		0.2:	
		Upton		0.3		
	17.0	Comstock	N = Aldebaran	1.1	1.05	
		Dunér	= Capella		0.22	
25	.....	Naegamvala	> or = : β Gem.		1.2±	
	4.8	Glasenapp		0.5	0·5	
	5.0	Borisiak		0.8	0.8	
	6.8	Robinson	Capella and α Persei	1.0	1.0	B†
	6 & 8	Kucera	>α & β Persei >α Aurigæ and α Tauri			LB
	7.0	Wickham	With 10-inch equatorial	0.86	0.87	B W
	7.5	Wickham	With naked eye	0.91	0.93	
	7.0	Köhl		0.80		
	8.0	Bellamy		1.3±		
		Gautier	< Procyon			Y W
	9.0	Marchetti		0.9		W
	9.0	Höhl		1.0		
	9.8	Gyllenskold	α, β Aurigæ, α, β Persei	1.39		
	9.9	Bohlin	α Aurigæ 10 N 4 α Persei	1.4	1.4	
	11.2	Yendell	Capella 1^m > N		1.22	
	11.5	Williams	Midway between α Aurigæ and α Persei	1.06	1.05	
	12.0	Seagrave	Betelgeuse 2 *N* 2 Pollux		1.07	
		Upton		1.0		
	12.5	Parkhurst		1.0		
	13.0	Micou	Procyon 3 N 1 α Orion; N β Gem.	0.75	0.80	Y W
	13.0	Olivier	0.6 < α Aurigæ; 0.5^m > β Gem.		0.72	
	13.2	Daniel		0.92		
	13.6	Wendell	Photometer	1.05	1.05	
	14.0	Brenke		1.0		
	14.2	Yendell	N (Capella — α Persei)	1.10	1.05	F Y
	15.0	Seagrave	Betelgeuse 1½ N 2 Pollux		1.03	
	22.8	Küstner	Between α Pers. and α Aur.	1.0±		W
26		Naegamvala	= : β Gem.		1.21	
	4.2	Glasenapp		1.4		
	6.0	Ambronn	1^m < Capella		1.2±	
	6.6	Sviatsky		1.6		
	6.8	Fauth	Between Castor & Pollux	1.5		
	6.8	Müller / Kempf	Photometer	1.62	1.37	W Y
	7	Kucera	Light and color unchanged			

* Color of Capella. † Capella yellow.

Date 1901.	Gr. M. T.	Observer.	Comparisons.	Magnitude. Obs'r.	Revised.	Color
Feb.	h					
26	7	Schwab	= α Gem.; α Aur. > N > α Pers		1.59	*
	8	Graff	> Castor and a little < Pollux		1.3	O W
		Gautier	< Procyon; = Regulus		1.37	Y W†
	8.4	Luizet		1.1		
	8.7	Messow	α Aur., α Can. Min., β Gem. > N > α Pers.		1.5±	‡
	8.7	Messow	N = α Urs. Maj. > γ Urs. Maj.		1.93	
	9	Höhl		1.6		W
	9	Marchetti		1.4		
	9.5	Plassmann	Capella 5 N		0.67	
	9.5	Rambaut	α, β Pers.; Pollux, Castor; Rigel, δ Pers.	0.95	0 96	
	10.0	Robinson	Capella, α Pers.	1.4	1.4	
	10-11	Wickham	13 stars	1.17	1.19	
	11.2	Yendell	(Capella — α Persei) 0.3 > N		1.35	
	11.5	Becker	Photometer	1.6	1.4	
		Gautier	< Procyon; = Regulus		1.37	Y W†
	11.5	Williams	3 steps > α Persei	1.64	1.66	Y
	12	Seagrave	Pollux 1½ N 2½ Castor		1.35	
	12.5	Parkhurst		1.1		
	13.0	Comstock	Aldebaran 6 N 3 α	1.65	1.61	
	13.0	Micou	α Tauri 2 N = β Gem.; N 1 α Leonis	1.30	1.24	
	13.2	Yendell	N 4 α Persei	1.42	1.48	
	14	Brenke		1.2		
	14	Wilson	N = α Tauri		1.05	
	14.6	Wendell	Photometer	1.49		
	14-16	Olivier	0.5^m > α Persei		1.4	
	14	Seagrave	Pollux 1½ N 2½ Castor		1.35	
	15	Seagrave	Pollux 1½ N 3 Castor		1.34	
	15.8	Hadden	Same as Aldebaran	1.0	1.05	
	16	Seagrave	Pollux 1½ N 3 Castor		1.34	
		Upton		1.2		
27		Naegamvala	< β Gem.; > α Gem.		1.4	
	5.0	Borisiak		1.6		
	7.0	Honnorat		1.8		
	7.2	Wickham	Capella, Aldebaran, Castor, α Pers., β Aur.	1.47	1.48	
	7.3	Robinson	Aldebaran, α and β Persei	1.53	1.56	
	7.5	Bellamy	N = β Tauri; nearly $\frac{1}{2}^m$ > α Persei = brightest star in Belt of Orion		1.73	
	8.0	Schwab	N 2 α Persei		1.7	¶
	8.3	Winkler	About 0.2^m > α Persei	1.8	1.7	Y
	8.8	Luizet		1.5		
	9	Fauth	N > α Persei	1.75		
	9.6	Hohl		1.8		YR
	9.6	Marchetti		1.7		
	9.9	Muller, Kempf	Photometer	1.99	1.76	W Y
	10.1	Graff	: = Polaris		2.1	O
	10.0	Luizet		1.9		
	11.	Seagrave	Castor 1½ N 1 α Persei		1.76	
	11.0	Luizet		2.0		
	11.2	Yendell	N (α Pers. — Algol)	2.13	2.14	

* Color of α Gem. † Same color as Capella. ‡ More violet than α Urs. Maj.
¶ Color of α Pers.

Date 1901.	Gr. M. T.	Observer.	Comparisons.	Magnitude.		Color
				Obs'r.	Revised	
Feb.	h					
27	11.3	Luizet		2.1		
	11.7	Luizet		2.1		
		Upton		1.9		
	12.3	Hagen	α 0 N 8 β		1.88	
	12.5	Zwack	N 2 α		1.74	
	12.5	Daniel		1.65		
		Comstock	N = α; N 3 β	1.95	1.99	
	13	Seagrave	α Persei 1 N α Arietis		2.10	
	13-15	Micou	α Leonis 5 N β Tauri 1 α Persei	1.8	1.80	
	13-15	Olivier	$0.1^m > \alpha$ Persei		1.8	
	13.5	Parkhurst		2.0		
	14	Brenke		1.7		
	14	Wilson	N = α Persei		1.88	
	14.5	Yendell	(α Pers.-Algol) 1 N	2.13	2.24	
	14.5	Wendell	Photometer	1.93		
28		Naegamvala	Not > α Gem.		1.6±	
	5.	Borisiak		1.70		
	6.6	Sviatsky		2.3		PY
	6.9	Kucera	Fainter, but > α Persei			
	7.	Robinson	Aldebaran, α Persei, Algol	1.65	1.68	
	7.4	Laska	α 2 β, N 1 α		1.6	
	7.5	Hohl		2.0		YR
	7.5	Kohl		1.78		
	8.	Schwab	A little brighter than α Persei			
	8.1	Wickham	10 stars	1.66	1.67	
	9.	Harkányi	Photometer	1.85	1.62	YW
	9.8	McClellan	7 stars	1.41	1.41	
	10.0	Williams	N 3 α	1.64	1.66	
	10.0	Bellamy	Certainly > α			
	11.2	Yendell	N 2 α		1.68	
		Sharp		1.6		
		Upton		1.8		
	12	Hagen	N 4 α		1.64	
	13	Zwack	N 4 α		1.60	
	13	Micou	α Leonis 4 N 2 α Gem.; N 2 α	1.7	1.61	R
	13	Olivier	$0.2^m > \alpha$		1.7	
	13.9	Daniel		1.65		
	14.0	Wendell	Photometer	1.83		
	14.0	Parkhurst	Photometer	1.90		
	14.2	Yendell	N 2-3 α Persei	1.72	1.63	
		Comstock		1.8	1.78	
	15.8	Hadden	= β	2.0	2.3	
	16	Hagen	N 4 α		1.64	
	16.5	Zwack	N 4.5 α		1.57	
Mar.						
1	4.9	Robinson	α	1.94	1.88	Y*
	5.0	Tatschaloff		1.8		
	6.5	Rambaut	α, β	2.03	2.05	
	6.5	Wickham	α, β	1.88	1.90	RY
	7.0	Bellamy	= α Per. and β Aur.; < β Tauri	2.00	1.9	
	7	Weinek	= α	2.0	1.88	Y
	7.2	Robinson	α, β	1.96	1.98	
	7.5	Nijland		2.02		
	8	Wickham	10 stars	2.01	2.01	
	8	McClellan	α	1.94	1.88	
	8.6	Luizet		2.15		

* Yellow with reddish tinge.

Date 1901.	Gr. M. T.	Observer.	Comparisons.	Magnitude. Obs'r.	Revised	Color
Mar.	h					
1		Meyer		2.1		
		Sharp		2.2		
	9.5	Williams	5 steps < α Persei	2.44	2.28	
	9.9	Nijland	With naked eye	2.64		
	9.9	Nijland	With opera glass	2.27		
	11.5	Rambaut	α, β	2.13	2.15	
	12.0	Williams	7 steps < α	2.64	2.44	
		Upton		2.1		
	13	Micou	α 3 N 1 β	2.25	2.24	
	13.7	Hagen	α 7 N 0 β		2.40	
	13.7	Zwack	α 3 N 4 β		2.10	
	15	Olivier	Same as β		2.40	R
	15.7	Wendell	Photometer	2.34		
	15.8	Brenke		2.5		
	16.0	Hadden	Brighter than δ	2.3		
2	5.6	Laska	α 2 β, β 2 N		2.9	
	6.2	Miclaucic		2.2		R
	6.5	Küstner	α 5 N 2 β		2.23	OY
	6.7	Archenhold	Algenib 1 N 3 Algol		2.0	R
	7.7	Archenhold	Algenib 3 N = Algol		2.3	
	8	Schwab	N = or < α	2.2		
	8	Messow	α > N > β			RY*
	8-9	Graff	: = α Cass.; < α Pers.		2.24	Y†
	11.2	Yendell	(α − β) 1 N	2.23	2.24	
	11.5-12.5	Hagen	N 2 β		2.28	
	12	Robinson	β Tauri, α and β Persei	2.05	2.02	R‡
	13	Young	α 4 N	2.3		
	13	Micou	γ Androm. 1 N; β Persei 1 N	2.28	2.41	DR
	13-15	Olivier	$0.17^m > \beta$		2.23	
	14	Wilson	α 2 N 1 β		2.23	
	14	Zwack	α 1 N 6 β ? ?		(1.95)	
	15	Brenke	N 1 β	2.3		
3	5.7	Laska	α 2 β, β 2 N		2.9	RY
	6.2	Messow	β Pers., β Urs. Min. γ Urs. Maj > N > 12 Can. Ven.; δ Urs. Maj.		2.7	R
	7	Ambronn	α, δ	2.5-2.8		DR
	7.0	Honnorat		2.3		
		Schwab				O¶
		Sharp		2.3		
	7.2	Williams	α 4 β 2 N 10 δ	2.41	2.41	W‖
	7.6	Sviatsky		2.4		RY
	8	Ventosa	= β : < α	2.2	2.4	R
	9.2	Robinson	β Tauri, α, β, ε, δ Persei	2.20	2.14	R
	10.0	Graff	< α			R§
	10.0	Küstner	γ Cass. 3 N 1 β Pers.; N = α Cass.		2.36	S**
	12	Schorr		2.3		
	12	Hagen	β 4 N 8 ε		2.58	
	13	Micou	β 5 N 1 ε	2.65	2.86	DR
	13-15	Olivier	$0.18^m < \beta$		2:58	
	13.5	Parkhurst	Photometer	2.71		
	13.8	Zwack	β 2 N 5 ε		2.65	

* Reddish yellow but less so than α T auri and α Can. Min. † Yellowish red like α Cass. and Pollux. ‡ Reddish; Algol and β Tauri bluish. ¶ Orange color in moonlight. ‖ White with perhaps a tinge of yellow. § Color like Mars. ** Same color as α Cass.

Date 1901.	Gr. M. T.	Observer.	Comparisons.	Magnitude. Obs'r.	Revised	Color
Mar.	h					
3	15	Brenke	β 3 N	2.7		
	15.0	Comstock	N = β; N = ($\alpha\epsilon$)	2.4	2.40	
4	4.6	Sviatsky		2.7		R*
	7.0	Glasenapp		2.8		
	7	Kohl	Quite a little > δ Persei			
	7.2	Messow	< β; < α Cass.; = δ Cass.; > δ and ϵ		2.8	
	7.2	Pola Obs.		2.2		R
	7.4	Winkler	> δ and ϵ	2.8		Y
	7.7	Riccó	< Polaris	< 2.2		
	8	Ventosa	< β and > δ	2.5		R
	8.4	Archenhold	α 8 N 6 δ	2.60	2.58	R
	9	Graff	= θ Aurigæ; : = Algol		2.7	YR
	10.3	Ambronn	δ 3 N 2 α; ϵ 2 N 1 β Aurigæ; ν 2 N 1 ϵ	2.52		R
	13.0	Comstock	β 2 N 4 δ	2.6	2.65	
	14.0	Parkhurst		2.8		
	14.0	Wilson	α 4 N 1 β; N = δ Cassiop.		2.65	
	16.0	Hadden		2.7		
5	4.6	Sviatsky		2.8		BR
	6.9	Williams	β 5 N 7 δ	2.65	2.69	W†
	7.0	Bellamy	N = δ Cassiop.	2.84	2.87	
	7.0	Honnorat		2.6		
	7.1	Wickham	15 comparison stars	2.36	2.37	VR
	7.1	Robinson	4 comparison stars	2.54	2.50	O‡
	7.2	Hohl		> 2.2		R
	7.7	Riccó	< α	< 2.67		
	8.2	Messow	ϵ > N > δ and ι Aurigæ		2.92	R
	9	Harkányi	Photometer	2.87	2.64	R
	9.9	Nijland	With naked eye	2.64		V¶
	9.9	Nijland	With binocular	2.27		‖
	12.7	Zwack	β 11 N 2 ϵ !		2.85	
	13.0	Parkhurst	Photometer	2.71		
	13.0	Brenke	β 5 N; β to N = α to β	2.8	2.75	
	13.0	Sperra	β 5 N 6 ι Aurigæ		2.60	
	13-15	Olivier	0.15^m < β		2.55	
	14	Micou	β 3 N 2 ι Aurigæ	2.52	2.70	
	14	Hagen	β 5 N 7 ϵ		2.62	
	14	Wilson	β Cass. > β Pers. > N > δ Cass. > γ Pers.		2.6	
	15.5	Hadden		2.7		
6	4.6	Sviatsky		3.3		O
	5.8	Pola Obs.	Four observers	2.5		R
	6.2	Bohlin	γ Androm. 2 N 4 δ; β 3 N	2.6	2.7	Y§
	6.5	Wickham		2.67	2.66	
	6.8	Robinson		2.88	2.85	
	7.0	Williams	β 8 N 4 δ; N 5 γ	2.83	2.84	
	7.0	Honnorat		3.0		
		Sharp		2.8		
	8.0	Bellamy	= ϵ or 0.1 or 0.2 < ϵ	2.90	2.95	
	8	Schwab	α > N 2 γ		2.9	
	8	Ventosa	< β; > or = γ	2.8		R
	8	Harkányi	Photometer	3.20	2.97	R

* Redder than Mars. † White; certainly no bluish or greenish tinge; 2¼-inch refractor. ‡ Orange red; deeper in color than Aldebaran, Betelgeuse or Mars. ¶ Violet of Kalium flame. ‖ Algol bluish white. § Brilliant gold yellow in refractor.

TO BE CONTINUED.

THE MOTION OF THE GREAT RED SPOT AND OTHER MARKINGS ON JUPITER.

W. F. DENNING.

For Popular Astronomy.

At about the middle of the year 1894, the position of the centre of the red spot coincided with the place of Mr. Marth's zero meridian, system II based on a rotation period of $9^h\ 55^m\ 40^s.63$. But the motion of the spot was most perceptibly slackening so that during the 6¼ years to 1900 September it had lost about 44 degrees (equivalent to 4368 seconds) relatively to the zero meridian. In the autumn of 1900, however, a marked increase of velocity appears to have set in for, during the 12 months ending 1901 September 24, the spot has been running as nearly as possible level with the period of $9^h\ 55^m\ 40^s.63$ and its present longitude is the same as it was in 1900 September. During the 6¼ years from 1894 June to 1900 September, the mean period of the object was $9^h\ 55^m\ 41^s.44$ increasing in different years as follows:

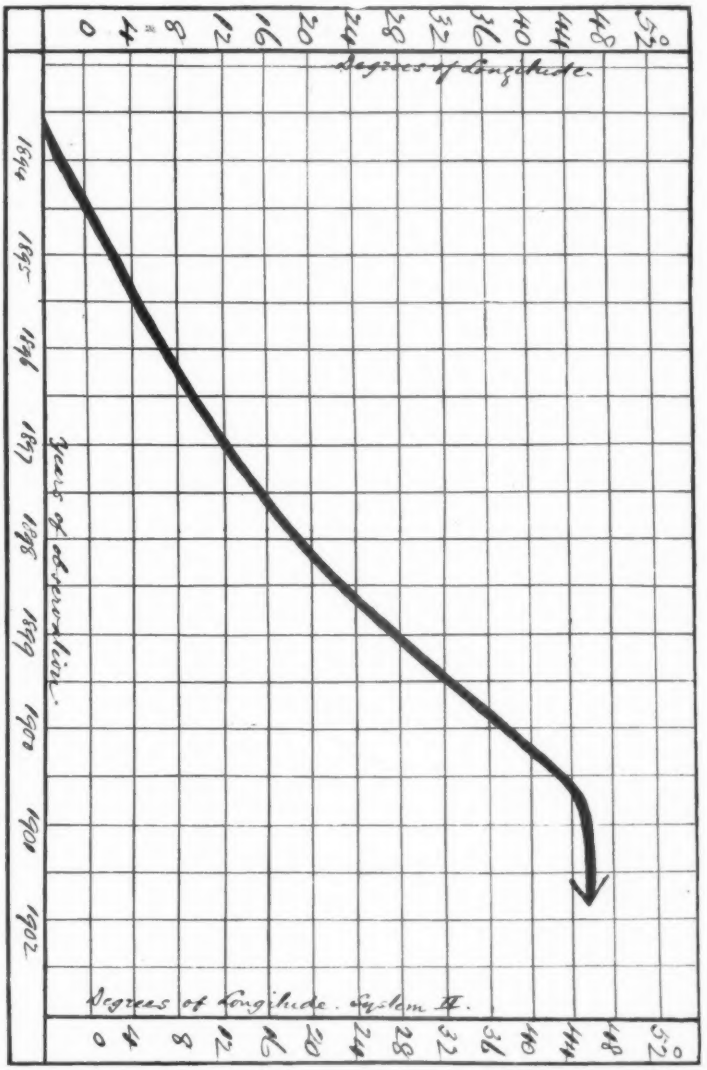
	h	m	s		h	m	s
1894	9	55	41.0	1898	9	55	41.6
1895	9	55	41.1	1899	9	55	41.7
1896	9	55	41.3	1900	9	55	41.7
1897	9	55	41.4				

The figures for 1901 prove that the period has been fully 1^s less or $9^h\ 55^m\ 40^s.6$. I select, from a considerable number of estimated transit times of the spot obtained at Bristol, a few to show the longitude of this marking during the last 7½ years:

Year.	Date.	G. M. T. h	m	Longitude. °	Year.	Date.	G. M. T. h	m	Long. °
1894	Mar. 24	6	46	357.9	1899	Aug. 8	8	9	33.7
	Nov 25	10	50	2.9		Sept. 14	3	59	34.7
	Dec. 12	9	46	0.7	1900	Jan. 8	20	22	36.4
1895	Mar. 28	7	28	4.4		Feb. 20	20	59	37.4
	Aug. 24	16	24	5.7		May 17	11	56	39.1
1896	Feb. 22	6	43	8.8		Sept. 3	7	10	44.4
	Sept. 27	17	43	8.9	1901	Feb. 13	17	37	43.4
1897	April 28	8	35	10.3		May 28	13	35	45.9
1898	April 15	10	26	22.6		June 24	10	46	44.7
	May 14	9	25	24.1		July 28	8	49	46.5
1899	Feb. 24	16	49	30.0		Aug. 9	8	38	43.5
	April 19	11	20	32.0		Sept. 5	5	59	43.5
	June 14	7	32	32.9		Sept. 24	6	46	44.5

I was interested in getting the observation on 1901 September 5 because exactly 70 years ago (1830 Sept. 5) Heinrich Schwabe at Dessau first drew the hollow on the great southern belt just as it appears today. During the long interval of 2,208,980,280 seconds separating Schwabe's observation from mine the planet

had performed 61813 rotations and the mean period was $5^h\ 59^m\ 36^s.56$. The observations were nearly all made with a 10-inch reflecting telescope power 312.



CHANGE OF LONGITUDE OF THE GREAT RED SPOT ON JUPITER.

The diagram will show the relative velocity of the spot during

the period under review. It remains to be determined by future observation whether the motion will be further accelerated during the few ensuing years.

There has recently been visible a large dark irregular marking on the S. margin of the great S. equatorial belt and in about the same latitude as the red spot. This new object was in longitude 233° on 1901 Aug. 3 and in 205° on Sept. 23. Its rotation period is $9^h\ 55^m\ 18^s$ and if it remains visible so long its preceding end will arrive at conjunction with the following end of the red spot in June 1902, when certain phenomena witnessed in the summer of 1890 will probably be repeated. It may be remembered that at the period referred to a number of dark spots on overtaking the red spot were described to the southward and were subsequently carried by their more rapid movement along the southern border of the latter object.

The conspicuous white and dark spots which alternate on the N. side of the S. equatorial belt have been moving much slower during the present apparition of the planet than in 1898, 1899 or 1900 and their mean periods of rotation have corresponded very nearly with that of System I of Marth-Crommelin's ephemerides ($9^h\ 50^m\ 30^s$). I have obtained about 350 transits of 28 of these equatorial spots during the past summer but have not yet reduced the observations. During the three preceding years (1898-1900) the mean period of a large number of similar spots was $9^h\ 50^m\ 24^s$, while the present opposition will exhibit a retardation amounting approximately to 6 seconds.

In 1901 the N. equatorial belt has been narrow and inconspicuous while the N. temperate belts have developed into striking prominence and have shown a number of irregular markings.

BRISTOL, 1901, Sept. 28.

THE ASTRONOMY OF THE NEBULÆ.

W. W. PAYNE.

Since the advent of photography into the field of astronomical work, the study of the nebulæ has advanced rapidly. A backward look for only a brief time, in the history of science, shows how this new branch of astronomy has come forward to a unique place in practical astronomy and widely popular interest. Not only the common question of what the nebulæ are, but the reasons for the answers that anybody can give are on demand by all who read and think by the aid of modern astronomical instruments.

If we go back to 1612, or about that time, we have reached very nearly, the beginning of our knowledge of this interesting class of celestial objects. It was at this time that Simon Marius, the German astronomer, discerned the difference between star-clusters and real nebulæ, at least, in one notable instance, and that was the nebula of Andromeda. When looked at with the telescope, it did not indicate a sidereal structure, common to the practiced eye of an observer, but it had a hazy look, a dull and nebulous aspect, totally different from that of the stars and the star clusters. It will be remembered that Ptolemy inserted in his catalogue five stars, which on account of their hazy look he called cloudy stars. They did indeed so appear to the naked eye and, as his catalogue was, the best he could do. When these same objects were viewed with the telescope, it was at once seen that they were star clusters and not nebulous in character at all. So far as the records go, it does not appear that the great nebulæ of Andromeda and Orion were known before they were seen by the aid of the telescope.

This view is strengthened by Huyghens' account of his own discovery in 1656 of the Great Nebula in the sword handle of the constellation of Orion, and, also by Halley's paper before the Royal Astronomical Society, in 1714, in which he described the nebulæ that he then knew, the total number of which was six, counting the two already mentioned. From this time, the number discovered increased more rapidly. In 1755 Lacaille had made a catalogue of of these objects amounting to 42, which he had observed while at the Cape of Good Hope, and of course, belonging to the southern hemisphere. His division of these new objects into three classes is interesting:

1. Those which indicated sidereal structure. 2. Those nebulous in appearance only, really stars massed closely together, and 3, stars surrounded by a nebulous substance. This attempt to classify these new and unknown objects was the next step in the astronomy of the nebulæ.

Work of the observation continued in this way until the time of Sir William Herschel, when the whole number of the nebulæ then known did not amount to 150. This noted man, in 1786, communicated to the Royal Society a catalogue of 1000 new nebulæ and clusters of stars. The prodigious labor that was involved in bringing out these results under the circumstances in which he observed is amazing, and quite sufficient to rank him as one of the very few of the world's great astronomers. But, really, this was only the beginning of the astonishing work that

followed. In 1789, his second catalogue of 1000 additional new nebulæ appeared and in 1802, a third catalogue of 500 more of similar objects was published. The work of classification was also developed, and carried forward on a basis of high scientific value that has been estimated by later astronomers as strictly and rigorously fundamental, from the point of view gained by visual observation. To give the prominence to this point due to it, we have repeated that part of Herschel's classification pertaining to the nebulæ, as Grant gives it in his history of Astronomy, page 566, as follows:

"VII. *Nebulæ.* These were suspected by Herschel to be so many collections of stars reducible to one or another of the three classes last mentioned, (viz: Clustering collections, and the Milky Way, groups of stars and star clusters), the nebulous aspect assumed by them being merely an illusion arising from the impossibility of discerning the stars individually, in consequence of the immense distance at which they are placed. Herschel calculated that the light from one of the faint nebulæ seen in his 40-foot telescope, must have occupied about 2,000,000 of years in its passage to the Earth, although traversing space at the rate of 192,000 miles in a second! Well might the illustrious astronomer remark that the telescope had the power of penetrating into time as well as into space."

"VII. *Stellar Nebulæ.* These were supposed by Herschel to be in all probability clusters of stars whose light, on account of their immense distance, is collected so closely into one point, that the only evidence remaining of their resolvability into discrete bodies, consists of the appearance of ours."

"IX. *Nebulous Stars.* According to Herschel the phenomena of this class were of two distinct kinds. One of those was nebulous only in appearance, consisting in reality of so many systems of clustering collections of stars contiguous to each other, like the series of clustering collections of which he had found the Milky Way to be composed. The other species of object consisted of those whose structure was purely nebulous. One of the most remarkable of such objects was the Great Nebula of Orion which Huyghens had discovered in 1656. In a comparison of his earlier with his most recent observations of this nebula, Herschel concluded that during the intermediate period it had undergone a sensible change of aspect, a circumstance that appeared to him clearly to indicate that its structure was not sidereal."

"*Nebulous Stars.* These are stars surrounded by a pale, nebulous atmosphere. Herschel had, in a former communication to

the Royal Society, directed the attention of astronomers to these remarkable objects. The star, in each case, appeared to be situated exactly in the center of the nebulosity, whence it was evident that they were connected together by some physical relation. The question with respect to the real nature of these objects, was supposed by Herschel to be involved in great obscurity. If the nebulosity consisted of stars so remote as to put on a milky appearance, it necessarily followed that the central body, which usually represented a star of the seventh or eighth magnitude, must possess enormous dimensions. If, on the other hand, the central body be supposed not to exceed the ordinary size of the stars, how small, argued Herschel, must be the remaining stars of the system, and how inconceivably great must be their compression to produce the observed nebulosity. Instead of adopting either of these hypotheses, Herschel was inclined to believe that the phenomenon arose from a star of the ordinary magnitude being involved in a shining fluid of a nature totally unknown."

"XI. *Planetary Nebulæ.* These are nebulæ of a pale uniform aspect, and of a perfectly round form. Like the objects of the preceding class, they appeared to Herschel to be of a very mysterious nature. If they were admitted to be suns, it would be difficult to account for the faintness of their light. On the other hand, the supposition of their being sidereal aggregations was at variance with their uniform structure."

XII. *Planetary Nebulæ with Clusters.* The objects of this class were suspected by Herschel to form the connecting link between nebulous stars and planetary nebulæ. This view of their nature suggested to him a conclusion which he subsequently developed at greater length. 'If' says he, 'we might suppose that a gradual condensation of the nebulosity about a nebulous star could take place, this would be one of them in a very advanced state of compression'."

Nine years later, in 1811, Herschel takes another step in making the science of the nebulæ. It appears in a paper to the Royal Society which gives his famous hypothesis of the transformation of nebulæ into stars. The points made in that paper were:

1. The nebulæ are assumed to be composed of a self-luminous substance of a highly attenuated nature, scattered throughout the celestial regions.

2. By mutual attraction of constituent parts nebulous substance would have a tendency to form distinct aggregations and for the same reason would gradually condense until the resulting

mass would have the "consistency of a solid body and become a star."

3. Similar reasoning would account for the star clusters, and later steps in the formation of planetary systems according to the Laplace hypothesis.

4. But the strong points in the hypothesis of Herschel was the excellent use he made of the gradual gradation of the nebulæ, from the faint, irregular forms to those of the planetary classes in constructing a system of development that should have rational significance, and show a unity in nature's great plan.

Most of the conclusions reached by Herschel were readily and quite generally accepted by astronomers, but some were not. Later astronomy does not confirm the changes in the nebulæ, as Herschel supposed, neither does it support his hypothesis in regard to the shining fluid thought to occasion the light of those objects he named nebulous stars. That there are some changes in the form and condition of the nebulæ, as time goes on observers with modern instruments do not doubt; but they are confident that much less of variation exists than was formerly supposed to take place in comparatively brief periods of time.

The work of discovery, observation and cataloging the nebulæ was continued by Halley, Lacaille, Dunlop and Sir John Herschel to 1833, when the last named observer published a catalogue containing 2,306 nebulæ and clusters, 500 of which were new. In 1847 Sir John Herschel published the "Results of Astronomical Observations made at the Cape of Good Hope." This catalogue contained 1708 nebulæ and clusters found in the southern hemisphere, based upon four years of work ending in the year 1838. These two great catalogues covering the nebulæ of the northern and the southern hemispheres, were supposed, as late as 1850, to contain all the nebulæ visible in a reflecting telescope of 18 inches aperture.

The next point of interest was the work of Lord Rosse with a reflecting telescope of three feet clear aperture, and especially the more powerful instrument of six feet aperture which he himself constructed. The aim of this observer was to re-examine some of the objects catalogued by the Herschels, and determine what might be learned in this way, by the use of greater telescopic power.

The results obtained by Rosse, in the use of these great instruments, contained many interesting details in regard to the structure of these bodies, and gave rise to questions which caused almost endless discussion for years afterwards. From the nature

of the case some of those questions were such that science could not then settle them. Astronomers did not, and could not, then grapple with them successfully, for the simple reason, as we now know, they had neither the necessary data nor the powerful astronomical instruments requisite for the crucial tests. A single example within the memory of the writer will illustrate the meaning intended to be conveyed. In April 1882, E. E. Barnard sent to the *Sidereal Messenger* a drawing of the Merope nebula in the Pleiades, as he had observed it, and gave with the drawings some notes relating to its discovery and the views of some observers that had appeared in print regarding the existence of the nebula, and by others its form and position. The difference of opinion as to its existence at all was very great then; and others who were satisfied that such a nebula did exist were not at all agreed in regard to its form and position. The writer was speaking of this nebula more than a dozen years later, to an able astronomer who had access to a large telescope, and the reader may possibly imagine our surprise, when that practical astronomer should say, "I do not believe there is any Merope nebula." Our answer was, "We are very sure of it, for we have photographed it." The nebula is as plainly seen on the plate as Barnard's drawing gives it. Besides all this some good observers had claimed to see the nebula in its proper place with a telescope of two inches aperture. With so small an instrument, it would, of course, require favorable conditions of observation, and possibly some knowledge of the appearance of the nebula in the telescope before-hand, in order to be sure of the observation. Other things being equal, it is certain that an astronomer can see more and see it better with a large instrument than with a small one. On this account, Rosse believed that it would be necessary to increase telescopic power if the new questions that had arisen in connection with his work were to be satisfactorily settled. The plan for future work suggested by him was, first, to make a careful delineation of all the different parts of each nebula studied for the purpose of comparison with other later drawings. After a long time of study in this way it was confidently hoped that some knowledge might be gained about the real structure of these very wonderful nebulous masses, singularly scattered every way in the depths of space. Then began the training of the eye and the hand for this new line of work which became somewhat popular with observers who were favored with large telescopes, and who were ready enough with pencil to sketch clearly and certainly in detail what should be revealed from time to time by the

telescope for the purpose of a permanent record. For more than a score of years this was the most promising way known for the study of the nebulæ, and it was faithfully followed by a goodly number of astronomers whose work is now on record in the libraries of some of the older Observatories of the world.

We now know that the limit of work on the nebulæ had been reached nearly when the great telescope of Rosse came into this fruitful field of observation. And instead of settling the differences of opinion then existing entirely, it introduced ten times as many more questions for investigation, some of which were new, as might be expected. This state of things called emphatically for new methods of research, and they came soon after in the spectroscope and in celestial photography.

From what we have said so far, a brief outline appears of the state of knowledge, and the methods of work and study in the astronomy of the nebulæ down to the time when the modern instruments largely replace the older ones. Next time the more recent study of the nebulæ will be considered.

THE COMING OPPOSITION OF EROS.

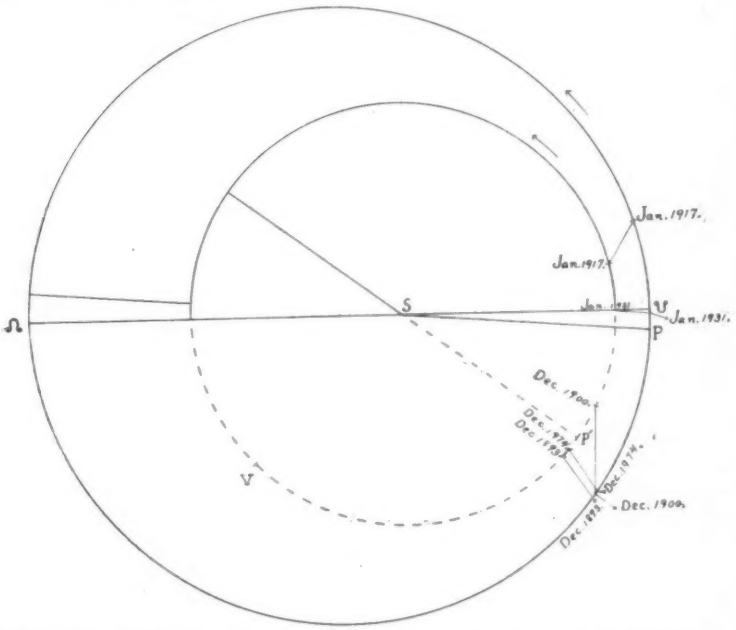
MARY CLARK TRAYLOR.*

For Popular Astronomy.

The planet Eros, which has proved of so much interest to the astronomical world, is at the present time too near the Sun for observation. On account of its large mean motion of 2015 seconds of arc daily, it will for several months lead the Earth a merry chase. During these months it will be south of the equator, traveling through the constellations Hydra and Scorpio. On Jan. 1, 1902, the date on which we first consider the planet's position, it is again traveling north, being at that time in R. A. $19^h\ 49^m$ and declination $-21°\ 51'$ in the constellation Sagittarius. At this time its magnitude, computed by the aid of data given in the *Berliner Jahrbuch*, will be 14.0. On Jan. 28 its distance from the Earth will become a maximum, about 257,000,000 miles. Eros will be in conjunction with the Sun on Feb. 5, 1902, their right ascension being about $21^h\ 13^m$. After this date it will drop westward of the Sun, and continuing its northward journey will cross the equator about April 1, 1902. It will travel northward until August 15, 1902, when its direction of motion will become southward; then crossing the equator again on Nov. 21, 1902, it will reach the point of its path farthest south on May

* University of Denver, class of 1902.

20, 1903. It will be in opposition with the Sun on June 9, 1903, and will on May 25 of that year be at a minimum distance from the Earth, about 61,000,000 miles. Its brilliancy will increase from the summer of 1902 until May 26, 1903, when it reaches a maximum magnitude of 10.7. It will then fade away rapidly until its magnitude will sink below 13.0 in October of the same year, after which there will be little opportunity of observing it, as it will again be close to the Sun.



THE RELATIVE POSITIONS OF EARTH AND EROS AT DIFFERENT OPPOSITIONS.

As much interest is now centered on the question of the variability of Eros, many measures of its brightness will doubtless be made during the coming months. In order that the law of its variability may become known, the results of these measures may well be compared with a system of standard values, computed on the assumption that the only change of brightness is that due to the variation in the relative position of the three bodies—the Earth, Sun and Eros.

Professor Barnard in a recent issue of *The Monthly Notices of*

the Royal Astronomical Society has said that at its nearest approach to the Earth, Eros, if it be single, should have a disc about one-half second in diameter, a distance which can be easily measured. If it be double, its duplicity can at that time be most easily detected. It is therefore very desirable to determine when this nearest approach will take place, that is, when Eros will be at its most favorable opposition. In December, 1893, occurred what is known as the most favorable opposition of recent times. It should be noted that, owing to the fact that the periodic time of Eros bears to that of the Earth the approximate ratio of seven to four, these favorable oppositions recur for a time at intervals of seven years. In December 1900 Eros was in good position for observation and in 1907 and 1914 will again be near the Earth.

By comparing tables of multiples of 365.25 days and 643.1 days—the periodic times of the Earth and Eros respectively—we find that after 23 revolutions of the Earth and 13 of Eros, they are again close neighbors. Counting forward 23 years from December 1893 we find that this nearest approach should occur in or near December 1916; but at that time the Earth is behind Eros and their relative position is not the best for observation. It is not until Jan. 1917 that the Earth, moving more rapidly, will overtake the little planet and the distance between them will become 25,700,000 miles. Another application of our first period of seven years determines another close approach in 1931, when the two bodies will be almost together on the line of nodes.

We now proceed to calculate the time of a more remote favorable opposition. Comparing the average daily motions of the Earth and Eros—3548 and 2015 seconds of arc respectively—we find that the Earth gains 1533 seconds of arc on Eros each day. Therefore the period required for the Earth to gain one complete revolution or 360 is 845.4 days. In order to determine the times of recurrence of very near approaches we proceed to find some number of synodic revolutions which will be approximately equal to an even number of revolutions of the Earth. From a table of multiples of 845.4 days it is apparent that 35 synodic revolutions are completed in 29589 days or almost exactly 81 years. Since 35 synodic revolutions consume almost the same amount of time as 46 sidereal revolutions, 46 revolutions of Eros are accomplished in about 81 years.

Favorable oppositions then recur in series, three of which we have determined—the first, in the relation of seven revolutions of the Earth to four of Eros, the second, in the relation of 23 revolutions of the Earth to 13 of Eros, and the third and most accur-

ate, in the relation of 81 revolutions of the Earth to 46 revolutions of Eros.

In the accompanying diagram the large and small curves represent the orbits of Eros and the Earth respectively. The dotted arc of the smaller curve represents that portion of the Earth's orbit which lies below the plane of Eros's orbit. The line of nodes, the perihelia of the Earth and Eros and the relative positions of the two bodies at the times of the favorable oppositions of 1890, 1900, 1917, 1931 and 1974 are indicated, and the connecting lines represent the distances between them at these times.

THE LIMITS OF VISION.*

EDWIN HOLMES.

Without being either an oculist or an optician, I have always felt great interest in questions relating to vision, and especially as to its limits and to alleged extraordinary instances, and I have come, after many years' attention, to the conclusion that if we eliminate the cases of defective organs, the sight of the remainder of mankind is of a fairly uniform character; and that this is especially the case as regards definition. If we leave out of consideration those who are shortsighted, the astigmatic, and the color blind, and cases of opacity of the cornea, or other organic defects, then the recorded instances of differences in powers of vision require explanation so far as normal eyes are concerned, if we accept them as related to us.

There are three separate yet connected questions to discuss. There is the question of what is the smallest visible area; there is the question of seeing faint objects and detecting faint shades, and the question of the perception of minute detail.

The reply to the question of the smallest visible thing, is that there is no assignable limit to the minuteness of visible objects. It is entirely a question of contrast. If an object is sufficiently brilliant on a dark background it will remain visible, however, minute it may be. This is easily proved. There are about 3,000 stars visible to the unaided eye at one time, and if all the light of the stars proceeded from these only, the average disc would be less than 1/164th of a second. A 6th magnitude would be much less, certainly not 1/1000th of a second, yet this minute object

* From *The Journal of The British Astronomical Association*, Volume XI, Number 9, July 26, 1901.

remains perfectly visible because of its brilliancy in contrast with the dark sky. Mr. Maunder experimented some years ago as to what were the smallest objects he could see, and came to the conclusion that 32″ to 36″ was his limit for a single spot, but a row of dots not more than 8″ each was perceptible as a diffuse line. His experiments are referred to in our *Journal*, Vol. V., page 144 and in *Knowledge*, for November 1894. I think Mr. Maunder only tried dark spots and lines of spots, and these areas and lines could only be seen and not defined. I am not aware that he tried bright objects on a dark ground, but there is no conflict betwixt his experiments and my statements. We do not define the star, we merely see it is there. Instead of appearing the 1/1000th of a second, it impresses our retina as if its light was spread over one or two minutes of arc, and in the case of a brilliant line, even if but a fraction of a second in thickness, we always see it at least one minute in breadth, and generally much more. But the visibility rapidly lessens as brilliancy diminishes, or as the background becomes lighter, until we reach the point where contrast fails. To prevent misconception, it is perhaps necessary to say I am applying this only to objects too small to cover an appreciable area or an appreciable breadth.

I do not think it is possible to lay down any exact rule regarding the preception of faint objects or faint shades. The sensitiveness of the retina is a variable quantity, like the sensitiveness of the photographic plate. The fact that one person or one hundred persons fail to see a faint object or a faint shade is not of the slightest value in disproving its existence to the one person who can see it. But exactly in proportion as extraordinary sight is claimed in this direction we are entitled to ask for proofs of its possession. If a person avers that he can see 8th magnitude stars with the unaided eye, we may properly hold his claim to be unproved unless his exceptional vision can be tested beyond dispute. Such test can never be convincing when made on an object known to be there. Seeing faint marks upon a planet after study with a larger telescope, or after learning its features by rote from a map, can never offer good enough proof to satisfy a doubter. Too many people see a thing if they know it is there. The late Herbert Sadler once sent me a list of stars alleged to have faint companions. I failed to see some of them, and asked him why he had not rather asked an observer who had a larger instrument in a better position. He replied that it was useless, because that observer, if told the stars were there, would be sure to see them.

The question of the perception of minute detail, or dividing and separating, is of a different character, and we have firm ground on which to form a judgment. The nature of light restricts the power of the human eye just as it does the power of the telescope or microscope, and we can reason from one to the other with perfect reliance on the conclusions we are led to. Now we know that 4″.56 divided by aperture in inches expresses the limit of the dividing power of a telescope, and as the aperture of the eye is about one-fifth of an inch we easily deduce 22″.8 as the limit of possible definition with the unaided eye, but neither eye nor telescope will divide two points so close without some magnifying power. A 12-inch telescope which divides to 0″.38 will not show two stars at that distance separated to a normal eye without a power of at least 300, and few will manage it at that—I think 500 will be needed, which is 42 to the inch. If, then, aperture of eye is one-fifth inch and 40 to the inch is required for clear definition, it is evident that a power of 8 would be required to see 23″, and that as we cannot apply this power, the distance must be increased 8 times, and 8 times 23″ is 184″, or roughly 3′ of arc. Now this agrees with experience, for eyes can see ϵ^1 and ϵ^2 Lyræ apart, and that is all. As they are 207″ apart, they are fairly over the limit I have laid down. I think separation with the naked eye of objects less than 3′ apart may fairly be set down as self-deception.

Of course the iris expands in darkness, but what is gained thus by increased aperture is lost by increased aberration. Definition is rather worse than better under such circumstances.

In Webb's *Celestial Objects*, there are some references to the visibility of the crescent of Venus and the satellites of Jupiter with the unaided eye, with mention of cases cited in the *Leisure Hour* for 1853, page 503. I think it necessary to give the date, because, after I had read a former paper acknowledged to be derived from the *Leisure Hour*, an unscrupulous anonymous writer in a well-known publication accused me of fabricating the whole story and imposing it on the British Astronomical Association. He had not even decency enough to ask me to give volume and page before branding me as the—shall I say?—novelist of the Association. The paper in the *Leisure Hour* claims for the writer to have seen Saturn and his rings misshapen. "The elongation was very apparent, not like the "satellites of Jupiter, at first suspected, guessed at, and then clearly discernible, but such a view as was most convincing." Several of his associates "at once told him in which direction the ring lay," which makes one

wonder at the wealth of visual power then collected in Armenia.

There is not, so far as I can find, any claim that anyone ever saw the ellipse of Saturn, the crescent of Venus, or the satellites of Jupiter previous to the invention of the telescope. The ancient observers who studied the heavens with so much assiduity seem never to have suspected anything, and Galileo's first intimations of his discoveries were met with incredulity. His telescope, magnifying 32 times, did not enable him to say what was the nature of Saturn and his appendages, and no less than 49 years elapsed before the explanation was given in 1659. Saturn and his rings at their nearest form a rough ellipse $40'' \times 18''$, so that they do not form an object of sufficient dimensions to make an impression of shape upon the retima, and it is obviously a case of self-deception. Most of these naked-eye observations are very indefinite as to dates, and, therefore, it becomes impossible to seriously examine the observations. In some cases much depends upon whether the planets were in opposition, and in the case of Jupiter's satellites, upon the position of the satellites. I can only suppose they were in opposition, and take the most favorable cases. Theodore Parker, at 12 years old, saw the crescent of Venus with the naked eye, not knowing it was a crescent beforehand. No date is given, and I cannot find Parker ever gave any other proof of exceptional sight. Stoddard saw her 'not round,' and with a dark glass saw the minute and beautiful crescent. Curiously he saw it better thus than with a telescope made of spectacle glasses magnifying six or eight times. Now Venus never exceeds 70″ in expanse of horns, which is not enough to form a definable area. If the middle of the crescent were cut away and only the points left, like two stars, they would be only one-third the distance apart of the components of ε Lyræ, and quite inseparable. There is an easy test any one can make. Take a telescope magnifying 27 times and turn its eye-piece towards our own crescent Moon and see if that is still visible as a crescent.

With regard to Stoddard's views of the satellites of Jupiter, we have no dates, but his sharp-sighted associates were never sure they could detect them. Stoddard saw them always at the same hour of the evening, always during twilight, and hardly for more than 10 minutes. They were visible when only 1st and 2nd magnitudes could be seen, and no 3rd magnitudes could be detected, although the brightest satellite is barely 6th magnitude, and close to a planet at least eight or nine magnitudes brighter. Again, we are not told whether Jupiter was in opposition at the time. There are other reported observations of these satellites

with the naked eye, which, without specifying, I will examine in the total. Satellite No. 1 never departs further from the limb of Jupiter than 120″, which is a little over half the minimum possible distance of visibility of two equal stars. I dismiss No. 1. No. 2 reaches 206″, or practically the distance the two stars of ε Lyræ are apart. Is it credible that a 6th magnitude can be seen so close to so bright a planet, either when 3rd magnitudes are invisible, or at any other time? 1 and 2 are alleged to have been seen as one. This could only happen when No. 2 was at No. 1's greatest elongation, or 120″ from Jupiter, and would be impossible if Jupiter was only of 5th magnitude. We may dismiss No. 2, either singly or in partnership. No. 3 is brighter, and may attain 343″, or 1¾ times the distance of ϵ^1 and ϵ^2. If any satellite has ever been seen with the unaided eye it is No. 3, but I confess I think the irradiation of Jupiter is too much for even this. No. 4 is too faint to be seen, even if degrees away from Jupiter, unless by eyes which can see 7th magnitude stars, but it might, when suitably placed, add its lustre to that of No. 3. But seeing the difficulty of dividing the two Lyræ stars of equal magnitude, it seems not possible that two stars with a difference of at least eight magnitudes can be seen apart at less than twice their distance.

The exceptional powers of vision attributed to uncivilized men, and to civilized men, who pass their lives in the open air, supposing they exist, are easily explained. They are only manifested while looking at familiar things which the supposed possessors of such sight have been long trained to see. The shepherd distinguishes sheep where the town-dweller sees nothing, because the one is accustomed to the place and objects, and the other not. The herdsman distinguishes cattle and the huntsman his prey, because they are practised, and see little differences which, perhaps, they cannot describe, but which they perceive almost unconsciously. The sailor and the longshoreman detect what the visitor fails to see out on the horizon, and will tell you of the peculiarities of rigging which enable them to distinguish one boat from another. Of course, they are used to these things, and undoubtedly see more, and also guess more, than the casual observer, for in my experience they are not seldom wrong. We have been told of the excellence of the Boer sight compared with that of British soldiers; but here, again, the Boer was in a country familiar to him, and its objects familiar, and he was mostly hidden, while the British soldier stood out in the open. Besides, many of the Boers possessed a good pair of binoculars, and hav-

ing picked up their enemy with them, they could see him after with the unaided eye.

The extent to which familiarity assists sight is scarcely appreciated, but is easily illustrated. We are all of us accustomed to see English as printed, and we catch, perhaps, three or four lines at a glance. Yet turn that printed page upside down, or turn your own writing upside down, and you can make out scarcely anything except a paper covered with indefinite marks. At a distance at which it is easily read in the ordinary position it will be impossible to read it reversed. The man whose sight is trained in a particular groove always sees more in that groove, and both savage and civilized men are trained in grooves. The civilized man sees what is hidden from the savage, and the town-dweller what is hidden from the shepherd, as well as the reverse.

I will mention two instances, rather because of my personal experience being concerned than for anything else. Thousands of people visit the Egyptian Hall at the Mansion House, and see the many large mirrors there without noticing anything particular about them. Now, the first glance I had at them caused me to remark what horribly bad glass the mirrors were made of. Those with me stared and I had to point out with some trouble what was so manifest to me. Again, ordinary window-glass has two sides, and it makes much difference in appearance of windows or pictures which side is outside. Either from carelessness or ignorance much glass is used the wrong way out. The trained eye sees this without even thinking of it. The untrained sees it not at all. But every one can corroborate this from his own experience, and thus justify the conclusion that there is not so much variation in keenness of sight as there is variation in ability to appreciate what is seen and familiarity with minute differences.

A final word about short sight. Short sight is inconvenient under ordinary circumstances, but a short-sighted eye is not necessarily a defective organ any more than a one-eighth micro-object-glass is defective because it will not define at 2 inches. A short-sighted eye is often very keen for objects within its working distance. On the other hand, it has been said that many of the most successful observers have been short-sighted, as if some special advantage in observing was due to short-sight. There does not seem any reason for short-sighted people being more successful than normal-sighted people, and I do not think there is a greater percentage of successful short-sighted observers than there is of short-sighted people among the population at large. While examining the image at the focus of a telescope without an

PLATE XVI.

MEDALS GIVEN TO DR. LEWIS SWIFT.

eye-piece, the short-sighted person can see a good deal more than the long-sighted, just as he can read smaller print, because he is able to look at the image from a distance of 3 inches, perhaps, where the long-sighted may have to recede to 20 inches. The short-sight has also an advantage with low power eye-pieces, since he still focusses closer to see distinctly. But as power increases, this advantage decreases, until with high powers, the difference betwixt long and short sight is so small as to be negligible.

DESCRIPTION OF MEDALS GIVEN TO DR. LEWIS SWIFT.*

LEWIS SWIFT, F. R. A. S.

All these medals except the Lalande and Gwilt were awarded me for single discoveries such as comets, while the other two were meritorious, including discoveries of both comets and nebulæ. They with a single exception are described in the order of their reception in Rochester, N. Y. and California.

Number 1; pure gold, diameter two and one-eighth inches, weight, two and one-half ounces avoirdupois. Obverse side reads: "Herr L. Swift für entdeckung des Cometen II, 1877." Translation: "Mr. L. Swift, for discovery of Comet II, 1877. Reverse: "Preis Zuerkannt von der K. Akademie der Wissenschaften in Wien." Translation: Prize awarded by the Imperial Academie of Sciences in Vienna.

Number 2 was for the discovery of Comet I, 1878.

Number 3 was for the discovery of Comet II, 1879. The last two are exactly like number one, except as to the number and year of the comet. All three are from Austria.

Number 4, the Lalande prize; silver medal and 500 francs; the third awarded to an American. On obverse side is a bust of a female and in raised letters, "Institut de France." Reverse side has within a wreath of depressed letters, "Academie des Sciences Prix Lalande Astronomie, Lewis Swift, 1881."

Number 5, of aluminum bronze, is nearly two and one-half inches in diameter. Obverse side shows a comet's tail, and in raised letters surrounding it are the words "Astronomical Society of the Pacific." On the reverse side: "This medal founded A. D. MDCCCXC, by Joseph A. Donohue, is presented to Lewis Swift,

* At our request Dr. Lewis Swift, now of Marathon, New York, has furnished us the photograph of his medals, and the brief description of them, accompanying.—THE EDITOR.

in commemoration of the discovery of a comet on March 6, 1892." This comet was discovered at the Warner Observatory, Rochester.

Number 6; obverse side is identical with number 5 and also with reverse excepting as to the date of the comet, which was Aug. 20, 1895. This was found at Lowe Observatory, California.

Number 7, is same as number 5 excepting that the date of the comet is April 13, 1898.

Number 8, is same as the preceding three excepting the date of the comet's discovery is March 20, 1895.

Number 9. This is the Mrs. Jackson Gwilt medal of bronze, three inches in diameter with "Lewis Swift" engraved on its edge. Obverse side has a medallion of Sir William Herschel, and round it near the edge in large raised letters is "William Herschel, MDCCXXXVIII, and MDCCCXXII." The reverse of this has a goddess standing on a world holding the Earth in her hands. Attached to her waist is a chain to represent the attraction that binds worlds together. Saturn, the crescent Moon and eighteen stars, some of which are double, are also depicted. Around all this in large raised letters are the words: "Jackson Gwilt Gift. Royal Astronomical Society." The whole design is unique and comprehensive, and emblematic of his discoveries.

As I was the first recipient of the Gwilt medal, it is but natural to suppose that I prize it highly. One hundred and twenty-five dollars came with it, which also was appreciated as is the case made for the medals in New York through the kindness of Mr. Gage Tarbull.

MARATHON, N. Y.

THE BRIGHTNESS OF STARLIGHT.

J. E. GORE, F. R. A. S.

It is probably a matter of common observation that on a clear moonless night it is never absolutely dark, even at midnight; a certain amount of light is given by the stars. What does this light amount to in terms say of full moonlight? Miss Clerke, in her "System of the Stars," gives the light of all stars down to 9½ magnitude as about 1/80th of full moonlight. M. G. l'Hermite found starlight equal to 1/10th of moonlight, but this estimate is evidently too high. The difference between a bright moonlight night and one illuminated by star-light alone is very considerable.

Let us make an attempt to estimate the total amount of starlight by computing the light emitted by all the visible stars down to the faintest point visible in the largest telescopes, like those of the Yerkes and Lick Observatories. The data available for this calculation are rather uncertain, but an approximation to the truth may perhaps be possible.

To express the total amount of starlight in terms of the light of a star of zero magnitude, like Arcturus, and thence in terms of moonlight, let us assume—as is now admitted by most authorities on this subject—that the total number of the visible stars is about 100 millions. Let us also assume that the "light ratio" is 2.512 (now accepted by all astronomers)—that is, that a star of zero magnitude gives 2.512 times the light of a star of the 1st magnitude, a star of the 1st magnitude 2.512 times the light of a 2nd magnitude star, and so on. To enable us to make this calculation it will be necessary to estimate the number of stars of each magnitude down to the 17th magnitude, which is about the faintest visible in the great Yerkes telescope, Dr. Gould, in his *Uranometria Argentina*, gives the following formula for computing the total number of stars visible in both hemispheres to any given magnitude, *m*:

$$\Sigma_m = 1.0051 \times (3.9120)^m$$

From this I find the following:

Magnitude.	No. of Stars.	Magnitude.	No. of Stars.
To 1.0 inclusive	3.93	To 10.0 inclusive	843,718
" 2.0 "	15.74	" 11.0 "	3,283,876
" 3.0 "	60.17	" 12.0 "	12,911,448
" 4.0 "	235.4	" 13.0 "	50,511,900
" 5.0 "	920.9	" 14.0 "	197,602,545
" 6.0 "	3602.5	" 15.0 "	773,021,071
" 7.0 "	14,093	" 16.0 "	3,024,057,632
" 8.0 "	55,131	" 17.0 "	11,830,114,720
" 9.0 "	215,674		

From this it will be seen that the formula gives for the fainter stars numbers enormously too large. For the brighter stars, viz, those of the 6th magnitude, the numbers seem to be rather small. Houzeau, who himself observed all the stars visible to the naked eye in both hemispheres, gives the following figures:

Magnitude.	No. of Stars.	Magnitude.	No. of Stars.
1	20	4	595
2	51	5	1213
3	200	6	3640
Total			5719

Accepting those figures, and adjusting the remaining magnitudes to suit a total of 100 millions down to the 17th magnitude, we obtain the following table:

1. Magnitude.	2. No. of Stars.	3. Light of each star in terms of zero mag.	4. No. of equivalent zero stars.	5 Remarks.
Above zero	2	—	7	Sirius and Canopus.
Zero mag.	1	1	1	Arcturus.
0-½	5	$\frac{1}{(2.512)^{\frac{1}{4}}}$	4	Capella, Vega, α Centauri, Rigel and Procyon.
½-1½	13	$\frac{1}{2.512}$	5	
1½-2½	51	$\frac{1}{2.512^2}$	8	
2½-3½	200	$\frac{1}{2.512^3}$	13	
3½-4½	595	$\frac{1}{(2.512)^4}$	15	
4½-5½	1213	$\frac{1}{2.512^5}$	12	
5½-6½	3640	$\frac{1}{2.512^6}$	14	To this magnitude, 6½, the numbers of the stars in each class have been assumed from Houzeau's results. The numbers in the fainter magnitudes have then been roughly adjusted so as to make the total about 100 millions. This may seem a rather arbitrary proceeding, but there is evidence to show that the stars really "thin out" below the 11th magnitude.
6½-7½	15,000	$\frac{1}{2.512^7}$	24	
7½-8½	50,000	$\frac{1}{2.512^8}$	31	
8½-9½	160,000	$\frac{1}{2.512^9}$	40	
9½-10½	628,000	$\frac{1}{2.512^{10}}$	63	
10½-11½	2,440,000	$\frac{1}{2.512^{11}}$	97	
11½-12½	6,000,000	$\frac{1}{2.512^{12}}$	95	
12½-13½	10,000,000	$\frac{1}{2.512^{13}}$	64	
13½-14½	14,000,000	$\frac{1}{2.512^{14}}$	35	
14½-15½	18,000,000	$\frac{1}{2.512^{15}}$	18	
15½-16½	22,000,000	$\frac{1}{2.512^{16}}$	9	
16¼-17½	27,000,000	$\frac{1}{2.512^{17}}$	4	
Totals.....	100,198,093		559	

It will be noticed that the numbers in column 4 of the above table rapidly diminish for the fainter magnitudes. If there were 100 millions of stars of the 20th magnitude their combined light would be only equal to that of a single star like Arcturus. From this it is clear that the light of all the stars below the 17th magnitude may be safely neglected.

In addition to the stars there are a large number of nebulæ

scattered over the surface of the heavens, but the majority of these are such faint objects that their combined light must be inconsiderable. Assuming a total number of 120,000 nebulæ and an average brightness for each equal to that of a star of the 8th magnitude, we have their combined light equal to 30 stars of zero magnitude. Hence the total light of all the stars and nebulæ in both hemispheres would be equivalent to that of 589 stars of zero magnitude like Arcturus. This estimate, of course, includes the Milky Way.

Now to find what fraction this is of moonlight we must consider some estimates which have been made of sunlight and moonlight. Huygens in the 17th century found the Sun 756,000,000 times brighter than Sirius; Michell in 1767 found 9,216,000,000; Wollaston in 1825-6, 20,000,000,000; Von Steinheil in 1836, 3,840,000,000; G. P. Bond in 1861, 5,970,500,000; and A. Clark found 3,600,000,000. The mean of all these rather discordant measures is:

Sun's light = 7,230,000,000 times light of Sirius. Modern photometric measures make Sirius about four times the brightness of Arcturus, and hence we have:

Sun's light = 28,920,000,000 times light of zero star.

Comparing sunlight with moonlight, Bouguer found the Sun 300,000 times the brightness of full moonlight; Euler found 374,000; Wollaston 801,072; G. P. Bond 470,980; and Zöllner 618,000. The mean of these is 512,810, but Zöllner's estimate of 618,000 is the one now generally accepted. Assuming this value, we have

$$\text{Moonlight} = \frac{28{,}920{,}000{,}000}{618{,}000}, \text{ or}$$

Moonlight = 46,800 times light of star of zero magnitude.

$$\text{Hence starlight} = \frac{589}{46{,}800} = \frac{1}{80} \text{ of moonlight.}$$

This result gives for *one* hemisphere (which is all that is visible from one place at one time)

$$\text{Starlight} = \frac{1}{160} \text{ of moonlight.}$$

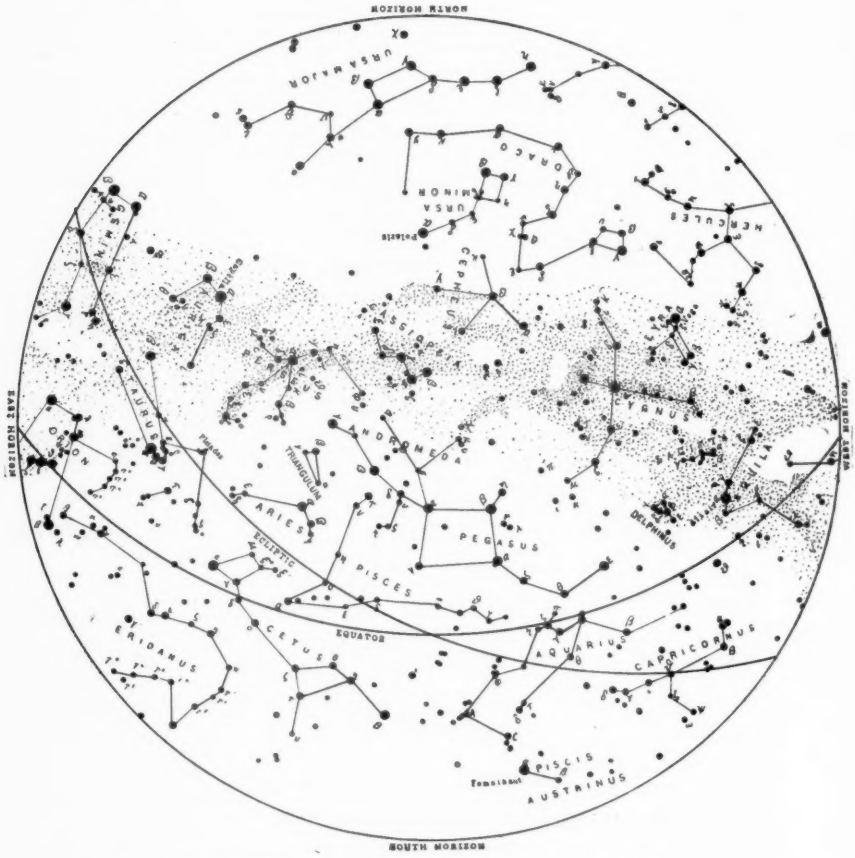
And this is probably not far from the truth.

An examination of the table will show that the combined light of the stars below 6½ magnitude is considerably greater than the light of those above that magnitude, so that if all the stars visible to the naked eye were extinguished we should still have nearly the same amount of starlight.—*Knowledge, August 1901.*

PLANET NOTES FOR NOVEMBER.

H. C. WILSON.

Mercury will be at inferior conjunction Nov. 4 at noon and so will not be visible to the naked eye during the first ten days of the month, but after that for a couple of weeks it may be seen in the southeast in the morning, from an hour to a half hour before sunrise. Mercury will be at greatest elongation, west from the Sun 19° 42′ Nov. 20.



THE CONSTELLATIONS AT 9 P. M., NOVEMBER 1, 1901.

Venus is in the lowest part of her path for the year in November and may be best observed by astronomers in the southern hemisphere. She is nearing greatest elongation east from the Sun, and the illuminated part of her disk is growing

less and less daily, so that at the end of the month it will be only half full. At the same time the brightness of the planet is increasing rapidly so that her brilliancy will be nearly a half greater at the end than at the beginning of the month.

Mars and *Uranus* will be in conjunction in Scorpio Nov. 3, Uranus being then 54′ north of Mars. The altitude of the two planets in the early evening is too low for satisfactory observations in this latitude.

Jupiter and *Saturn* will be in conjunction at midnight, Central Standard time, Nov. 27. Early on that evening the two planets will be within the same field of view, if one uses an eye-piece of very low power. Unfortunately the planets will be at such a low altitude at the time when we can observe them, that we can expect no very satisfactory views of them. Observers south of the equator will be better favored.

This month ought to be one of violent meteorological disturbances, if there is anything in the conjunction theories of the weather, for not only do we have the conjunction of the two giant planets to expect, but Venus will be in conjunction with the two in turn, with Saturn at midnight of the 17th and with Jupiter an hour after midnight of the 18th.

A correspondent asks when Jupiter and Saturn will again be together in the same constellation. Of course next year at this time they will not be very far apart nor very far from the same region of the sky, Jupiter having moved eastward about 30° and Saturn about 13°; but to find another conjunction in just the same longitude we should have to find the least common multiple of their periods and that of the Earth. Calling the period of Jupiter 11 6/7 years, that of Saturn 29½ years and that of Earth 1, the least common multiple in whole years is $14 \times 29\frac{1}{2} \times 11\ 6/7 = 59 \times 83 = 4897$ years. The planets will be near each other, within the limits of the same constellation, in 59 years, for two periods of Saturn = 58.92 years and five periods of Jupiter = 59.30 years, so that just 59 years from now Saturn will be about 1° east and Jupiter about 9° west of its present position.

Neptune's position on Nov. 15 will be R. A. $6^h\ 4^m$; Decl. + 22° 15′, the planet moving very slowly westward.

The Moon.

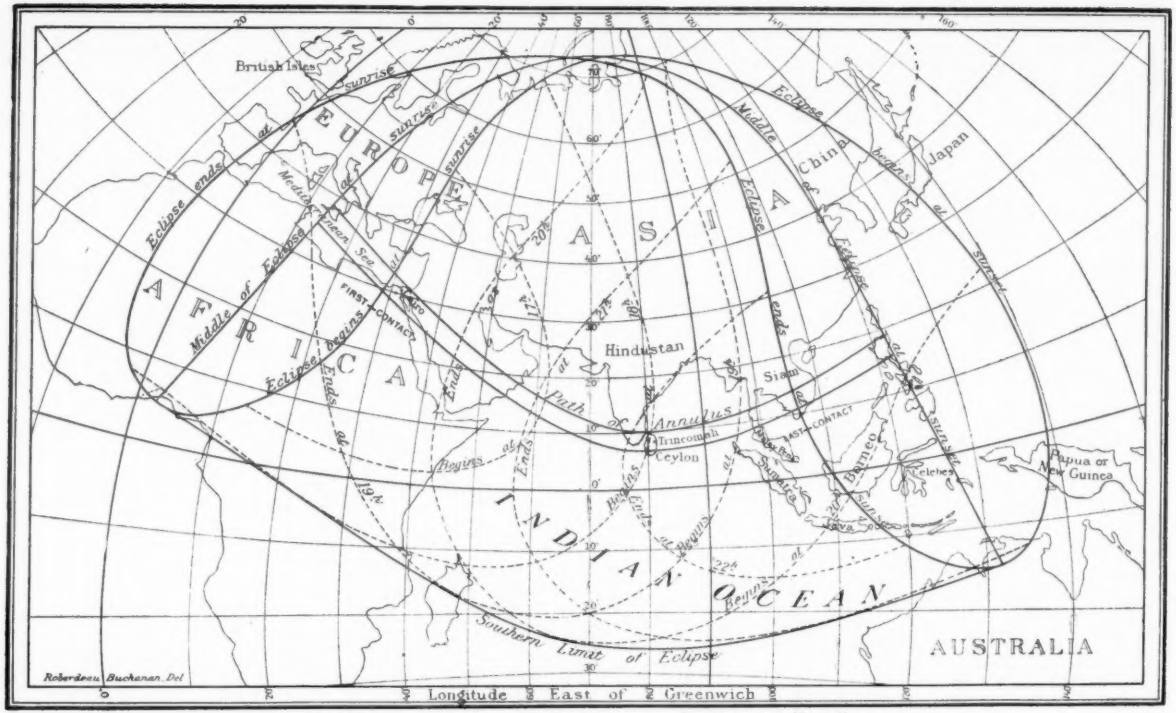
	Phases.	Rises. (Central Standard Time at Northfield; Local Time 13m less.)	Sets.
		h m	h m
Nov. 3	Last Quarter	11 13 P. M.	1 17 P. M.
11	New Moon	7 22 A. M.	5 9 "
19	First Quarter	12 54 P. M.	12 36 A. M.
25	Full Moon	4 35 "	7 56 "

Occultations Visible at Washington.

Date. 1901.	Star's Name.	Magnitude.	IMMERSION. Washington M.T.	IMMERSION. Angle f'm N pt.	EMERSION. Washington M. T.	EMERSION. Angle f'm N pt.	Duration.
			h m		h m	°	h m
Nov. 2	A^2 Cancri	5.8	10 58	88	11 52	294	0 54
2	60 Cancri	5.7	15 51	75	16 49	326	1 08
30	ω Leonis	5.6	14 32	109	15 54	299	1 22

Annular Eclipse of the Sun, Nov. 10.—This will be invisible in America. The partial phases will be visible in portions of Europe, Asia, Africa and

Annular Eclipse of Nov. 10th 1901.



Note-*The hours of beginning and ending are expressed in Greenwich Mean Time.*

Australia. The path of the annulus begins in the Mediterranean Sea and passes over Cairo, Egypt, crosses Arabia, the southern point of Hindustan, the Island of Ceylon, the Malay Peninsula and Siam and ends in the Philippine Islands.

ELEMENTS OF THE ECLIPSE.

Greenwich mean time of conjunction in right ascension, Nov. 10, $19^h\ 18^m\ 03^s.2$.

Sun and Moon's R. A.	$15^h\ 03^m\ 00^s.48$	Hourly motions	$10^s.12$ and $121^s.42$
Sun's declination	$-17°\ 15'\ 41''.7$	Hourly motion	$-\ 0'\ 41''.9$
Moon's declination	$-16\ 49\ 40\ .8$	Hourly motion	$-\ 5\ 33\ .8$
Sun's equa. hor. parallax	8.9	Sun's true semidiam.	$16\ 09\ .6$
Moon's equa. hor. parallax	$53\ 56\ .0$	Moon's true semidiam.	$14\ 41\ .1$

CIRCUMSTANCES OF THE ECLIPSE.

	Greenwich Mean Time.	Longitude from Greenwich.	Latitude.
	h m	° ′	° ′
Eclipse begins	Nov. 10 16 29.8	27 34.3 E.	26 46.0 N.
Central eclipse begins	17 43.7	13 34.0 E.	35 55.7 N.
Central eclipse at noon	19 18.1	66 29.9 E.	11 44.6 N.
Central eclipse ends	21 13.2	122 07.9 E.	17 20.8 N.
Eclipse ends	22 27.2	107 01.7 E.	6 59.8 N.

COMET AND ASTEROID NOTES.

Elements of Comet 1901 I.—Mr. C. J. Merfield gives a new set of elements of this comet, in *Astr. Nach.* No. 3739, which depend upon three normal places, May 6.5, May 22.0 and June 6.5. A slight eccentricity is indicated but the author assumes the following parabolic elements as nearly correct:

$$T = 1901\ \text{April}\ 24.2533\ \text{Gr. M. T.}$$
$$\omega = 203°\ 2'\ 22''.5$$
$$\Omega = 109\ 38\ 37\ .5$$
$$i = 131\ 5\ 40\ .0$$
$$\log q = 9.3889178$$

Encke's Comet.—This comet passed the Sun in September and is now an evening object, two hours east of the Sun, but so far to the south as to be a difficult object in our latitude. It will be easily observed in the southern hemisphere. The following ephemeris, by Ch. Thonberg, is contained in *Astr. Nach.* No. 3740:

EPHEMERIS OF ENCKE'S COMET.

1901	R. A.	Decl.	log r	log Δ	Aber.-Time.
	h m s	° ′			m s
Nov. 1	16 25 48	-28 13.6	0.0280	0.2499	47
2	30 40	28 22.9	0345	2539	14 55
3	35 28	28 31.5	0408	2580	15 3
4	40 12	28 39.3	0470	2620	11
6	49 27	28 52.6	0590	2701	28
8	16 58 26	29 3.4	0706	2781	15 46
10	17 7 9	29 11.8	0817	2861	16 4
12	15 36	29 18.1	0924	2940	21
14	23 49	29 22.3	1027	3018	39
16	31 47	29 24.6	1126	3095	16 57
18	39 31	29 25.4	1222	3172	17 15
20	47 3	29 24.7	1315	3246	33
22	17 54 22	29 22.6	1404	3321	17 51
24	18 1 27	29 19.3	1491	3392	18 9
26	8 22	29 14.8	1576	3463	27
28	15 5	29 9.3	1657	3534	18 45
30	18 21 38	-29 2.8	1.1736	0.3502	19 3

Ephemeris of the Asteroid (334) Chicago.

[By Dr. A. Berberich in A. N. 3741].

1901.	R. A.			Decl,			log. *r.*	log Δ.
	h	m	s	°	′	″		
Nov. 1	3	43	19.74	+13	29	14.4	0.5864	0.4633
2		42	42.87	13	26	44.6		
3		42	05.46	13	24	14.8	0.5865	0.4621
4		41	27.55	13	21	45.1		
5		40	49.19	13	19	15.5	0.5865	0.4611
6		40	10.40	13	16	46.2		
7		39	31.21	13	14	17.4	0.5865	0.4603
8		38	51.66	13	11	49.2		
9		38	11.78	13	09	21.8	0.5865	0.4596
10		37	31.61	13	06	55.2		
11		36	51.19	13	04	29.7	0.5865	0.4591
12		36	10.56	12	02	05.4		
13		35	29.75	12	59	42.3	0.5865	0.4588
14		34	48.81	12	57	20.6		
15		34	07.77	12	55	00.5	0.5865	0.4587
16		33	26.67	12	52	42.1		
17		32	45.56	12	50	25.5	0.5866	0.4588
18		32	04.46	12	48	10.9		
19		31	23.42	12	45	58.3	0.5866	0.4509
20		30	42.47	12	43	48.0		
21		30	01.66	12	41	40.0	0.5866	0.4595
22		29	21.01	12	39	34.5		
23		28	40.58	12	37	31.7	0.5866	0.4601
24		28	00.39	12	35	31.6		
25		27	20.47	12	33	34.3	0.5867	0.4609
26		26	40.87	12	31	40.0		
27		26	01.61	12	29	48.7	0.5867	0.4619
28		25	22.74	12	28	00.7		
29		24	44.27	12	26	16.0	0.5867	0.4631
30		24	06.24	12	24	34.8		
Dec. 1		23	28.68	12	22	57.1	0.5867	0.4644
2		22	51.62	12	21	23.0		
3		22	15.09	12	19	52.6	0.5868	0.4659
4		21	39.12	12	18	25.0		
5	3	21	03.75	+12	17	03.2	0.5868	0.4676

Elements of Asteroids 1901 FV, FX, FY.—These elements computed by Dr. A. Berberich are given in *A. N.* 3741:

	FV	FX	FY	
Epoch	1901 Jan. 9.5	1901 Jan. 23.5	1901 Feb. 11.5	
M =	92° 54′ 00″.7	294° 39′ 46″.9	55° 52′ 57″.2	
ω =	252 34 12 .3	261 29 42 .2	91 49 11 .7	1901.0
Ω =	103 44 20 .8	291 43 08 .8	323 48 28 .8	1901.0
i =	10 51 48 .3	19 17 15 .1	6 24 22 .6	1901.0
ϕ =	14 39 57 .7	3 58 23 .0	6 20 17 .4	
μ =	742″.582	581″.203	704.″103	
log a =	0.452841	0.523786	0.468247	

Elements of Planet (454) Mathesis.—Mr. W. I. Milham gives the following elements in *A. N.* 3741, based upon seven normal places from April 2 to June 22, 1900:

$M = 353° 06′ 49″.7$
$\omega = 174 20 14 .5$
$\Omega = 32 33 28 .4$ } 1900.0
$i = 6 19 15 .0$
$\phi = 6° 18′ 51″.5$
$\mu = 833″.1458$
$\log a = 0.419523$

New Elements of Asteroids (82), (113), (241) and (247.)—The following elements, computed by Wilhelm Luther, of Düsseldorf, all depend upon normal places derived from the published observations each year since the discoveries of the planets, and represent those normals very closely:

Elements of (82) Alkmene.
Epoch 1877 Sept. 21.0 Berlin M. T.

$M =$	238°	21′	21″.6	
$\pi =$	132	05	02 .2	
$\Omega =$	26	56	44 .6	1880.0
$i =$	2	51	02 .5	
$\phi =$	12	49	33 .9	

$\mu = 772''.734665$

Elements of (113) Amalthea.
1871 Mar. 27.0 Berlin M. T.

343°	27′	30″.2		
199	07	54 .9		
123	03	56 .2		1870.0
5	02	28 .6		
4	54	42 .8		

$968''.85258$

Elements of (241) Germania.
Epoch 1884 Aug. 15.0 Berlin M. T.

$M =$	10°	24′	35″.9	
$\pi =$	341	39	49 .5	
$\Omega =$	272	22	29 .7	1880.0
$i =$	5	30	16 .1	
$\phi =$	5	51	57 .0	

$\mu = 666''.46400$

Elements of (247) Eukrate.
March 3.0 Berlin M. T.

92°	30′	43″.8		
53	45	53 .0		
0	15	59 .7		1885.0
25	08	01 .8		
13	51	53 .0		

$781''.3222667$

The following elements also of the planet 1901 FX have been computed by S. K. Winther of Copenhagen from observations Jan. 19, Feb. 10, and Feb. 25, 1901:

Elements of 1901 FX.
Epoch 1901 Jan. 19.5, Berlin M. T

$M =$	293°	29′	20″.8		$\phi =$	3° 37′ 51″.8	
$\omega =$	291	21	16 .8		$\mu =$	581″.9514	
$\Omega =$	201	44	58 .6		$\log a =$	0.523414	
$i =$	19	22	23 .5				

VARIABLE STARS.

Nova Persei.—The nova is still visible with an opera-glass. Its fluctuations are not very marked now, ranging somewhere between 6.5 and 7.0 magnitude.

T Cephei. Correction.—We are sorry to have caused some of our readers trouble by an error in the August and September number. On page 408 in three places "τ Cephei" should read T Cephei.

U Persei and Eros.—In *Astr. Nach.* No. 3740 Mr. F. A. Bellamy calls attention to the fact that U Persei was near its minimum at the time Eros was in its vicinity. In the Harvard *A. G.* catalogue, the star 921 is U Persei and the four Harvard observations were made near its maximum (8.8, 9.0, 8.4, 8.8) and the observer looking for that star might expect to find a comparatively bright object, whereas it may have been actually below 11 magnitude.

New Variable Star 77, 1901 Herculis.—Dr. T. D. Anderson announces that he has discovered variability in the light of the star BD. 7°3199 whose place for 1855.0 is

R. A. $16^h\ 25^m\ 49^s.7$; Decl. $+7°\ 8'.9$.

Two or three years ago the star was noted as 9.0 instead of 9.5 as stated in the BD., while on Aug. 19 and 21 it was invisible in a 3-inch telescope, a 10^m star near by being visible on both occasions.

Minima of Variable Stars of the Algol Type.

[Greenwich Mean Time beginning with midnight. The hours greater than 12 are those of the afternoon. To obtain Eastern Standard time subtract 5 hours; for Central Standard subtract 6 hours.]

U Cephei.

d	h
Nov. 1	23
4	10
6	22
9	10
11	22
14	10
16	22
19	9
21	21
24	9
26	21
29	9

Algol.

Nov. 3	22
6	18
9	15
12	12
15	9
18	6
21	2
23	23
26	20
29	17

λ Tauri.

Nov. 3	3
7	2
11	1
15	0
18	23
22	22
26	20
30	19

R Canis Maj.

Nov. 1	7
2	10
3	13
4	17
5	20
6	23
8	2
9	6
10	9
11	12
12	15
13	19
14	22
16	1
17	4

R Can. Maj. (cont).

d	h
Nov. 18	8
19	11
20	14
21	17
22	21
24	0
25	3
26	7
29	10

S Cancri.

Nov. 3	18
13	6
22	17

U Coronæ.

Nov. 2	23
6	10
9	21
13	8
16	18
20	5
23	16
27	3
30	14

U Ophiuchi.

Nov. 1	18
2	14
3	10
4	6
5	2
5	22
6	18
7	15
8	11
9	7
10	3
10	23
11	19
12	15
13	11
14	8
15	4
16	0
16	20
17	16
18	12
19	8
20	4
21	0

U Ophi. (cont).

d	h
Nov. 21	20
22	16
23	12
24	8
25	5
26	1
26	21
27	17
28	13
29	9
30	5

Z Herculis.

Nov. 1	3
3	4
5	3
7	4
9	3
11	4
13	3
15	4
17	2
19	4
21	3
23	4
25	3
27	4
29	3

V^2 Cygni.

Nov. 1	4
7	4
13	4
19	4
25	5

U^3 Cygni.

Nov. 3	23
8	13
13	3
17	17
22	7
26	20

W Delphini.

Nov. 5	7
10	3
14	22
19	17
24	13
29	8

Y Cygni.

d	h
Nov. 2	2
3	10
5	4
6	10
8	2
9	10
11	4
12	10
14	2
15	9
17	3
18	9
20	1
21	9
23	3
24	9
26	1
27	9
29	3
30	9

S Antliæ.

Period $7^h\ 46^m.8$

Nov. 1	18
2	17
3	17
4	16
5	15
6	15
7	14
8	13
9	13
10	12
11	11
12	11
13	10
14	9
15	9
16	8
17	7
18	7
19	6
20	5
21	5
22	4
23	3
24	3
25	2
26	1
27	1
28	0
28	23
29	23
30	22

Variable Stars of Short Period not of the Algol Type.

	Minimum.		Maximum.			Minimum.		Maximum.	
	d	h	d	h		d	h	d	h
T Vulpeculæ	Nov. 1	1	Nov. 2	10	Y Sagittarii	Nov. 15	11	Nov. 17	6
X Cygni	1	3	7	22	W Sagittarii	15	15	18	15
X Sagittarii	1	16	4	13	X Sagittarii	15	17	18	14
ζ Geminorum	3	17	8	17	X Cygni	17	12	24	7
Y Sagittarii	3	22	8	17	β Lyræ	17	16	20	21
δ Cephei	4	1	5	16	T Vulpeculæ	18	19	20	5
η Aquilæ	4	20	...		η Aquilæ	19	4	...	
T Vulpeculæ	5	11	6	20	U Sagittarii	19	9	22	9
β Lyræ	5	18	8	23	δ Cephei	20	3	21	18
U Sagittarii	5	21	8	21	Y Sagittarii	21	5	23	0
S Sagittæ	6	11	9	21	U Aquilae	21	10	23	14
U Geminorum	6	15	9	6	U Geminorum	22	2	24	18
U Aquilae	7	9	9	14	X Sagittarrii	22	17	25	14
W Sagittarii	8	0	11	0	T Vulpeculae	23	5	24	15
X Sagittarii	8	17	11	14	W Sagittarii	23	5	26	5
δ Cephei	9	10	11	1	S Sagittae	23	6	26	16
Y Sagittarii	9	16	11	11	ζ Geminorum	24	0	29	0
T Vulpeculae	9	22	11	8	β Lyrae	24	3	27	5
β Lyrae	11	5	14	7	δ Cephei	25	12	27	3
η Aquilae	12	0	...		U Sagittarii	26	2	29	2
U Sagittarii	12	15	15	15	η Aquilae	26	8	...	
ζ Geminorum	13	20	18	20	Y Sagittarii	27	0	28	19
T Vulpeculae	14	8	15	18	T Vulpeculae	27	16	29	2
W Geminorum	14	8	16	23	U Aquilae	28	10	30	14
U Aquilae	14	9	16	13	X Sagittarii	29	17	32	14
δ Cephei	14	19	16	10	W Geminorum	29	19	32	10
S Sagittae	14	21	18	7	β Lyrae	30	14	33	19
T Monocerotis	14	23	22	22	δ Cepnei	30	21	32	12

Maxima and Minima of Variable Stars.

	Maxima.		Maxima.		Minima.
Nov. 1	R^2 Aquilae	Nov. 21	V Andromedae	Nov. 1	V Aurigae
1	X Librae	24	R Hydrae	2	R Draconis
5	U Monocerotis	25	T Delphini	2	S Corinae
5	U Pavonis	26	S Ursa Majoris	9	W Aquarii
8	R Horologii	26	X Herculis	9	X Aquarii
9	X^2 Sagittarii	27	S Lyrae	9	W Capricorni
10	S Columbae	27	R^2 Cygni	12	S^2 Librae
11	R^2 Aquarii	27	V Lyrae	13	T^2 Sculptoris
11	S Pic. Austr.	27	Y^2 Scorpii	15	*I* Carinae
11	W Ceti	28	Z^2 Scorpii	15	S Cephei
19	U Puppis	28	X Scorpii	22	W Puppis
20	S Sculptoris	28	Z Aquilae	22	R Ophiuchi
21	R Lyrae	28	*I* Carinae	23	S Vulpeculae
21	R Böotis	30	R Sagittarii	24	W Lyrae
				25	R Sagittae
				26	S Ursa Min.

Maxima of U Pegasi.

[Period $4^h\ 29^m\ 8^s$; the minimum takes place $2^h\ 15^m$ after the maximum].

	d	h		d	h		d	h		d	h
Nov.	1	20	Nov.	9	21	Nov.	17	23	Nov.	25	20
	2	18		10	19		18	21		26	22
	3	21		11	23		19	20		27	21
	4	20		12	21		20	23		28	19
	5	18		13	20		21	21		29	22
	6	21		14	23		22	20		30	21
	7	19		15	21		23	23			
	8	22		16	20		24	21			

New Variables in Perseus.—When using Kappa and Nu Persei as comparison stars for the Nova, I found Kappa the brighter of the two, as mentioned in POPULAR ASTRONOMY No. 86, page 354. I did not detect any variation in its light. In the Harvard Photometry it is classed as two-tenths less in magnitude than Nu. Near the horizon and also in moonlight orange stars gain in relative brightness. 36 Persei is classed as two-tenths less than 32, but on April 6th, I noted in my record that the difference was greater than that amount; but on the 8th and 9th of April thought that the assigned value was nearly correct.

SAN FRANCISCO, Sept. 20th, 1901. ROSE O'HALLORAN.

U Lyræ.—According to the "Companion to the Observatory" a minimum of this long period variable was due on May the 8th and a maximum on August the 21st of this year. About sixty observations were obtained between April 21st and September 14th but the following list includes only those showing distinct gradations and some seeming fluctuations. Clouds hindered observation from August 2d to 24th but no doubt it was clear elsewhere during the time of the expected maximum. Three days after that date it had fallen to 9.4 magnitude, and unless the decline was very rapid, it is probable that the maximum occurred long before the date of prediction, as it had risen to 8th magnitude seven weeks previously.

On April 21st, 26th, May 4th, 7th and 8th it was invisible in a 4-inch lens.

May 17th. Equal to *t*, classed as 12th magnitude.
" 23d. Equal to *g* of 10th magnitude.
June 2d. Brighter than *g* but less than *a* of 8.6 magnitude.
" 4th. Not so near the brightness of *a* but equal to *p* of 9.4 magnitude.
" 10th. Equal to *e* of 8.8 magnitude.
" 21st. Brighter than *e* but not fully equal to *a*.
" 23d. Equal to *a*.
" 29th. Slightly brighter than *n* of 8.1 magnitude.
July 3d. Equal to *n*.
" 5th. Brighter than *n*.
" 7th. Equal to *n*.
" 8th. Brighter than *n*.
Aug. 1st. Equal to *n*.
" 24th. Less than *n*, equal to *p*.
Sept. 7th. Equal to *f* of 10th magnitude.
" 14th. Equal to *g* which seems fainter than *f* probably only one-tenth.

The comparison stars used are those furnished in POPULAR ASTRONOMY, No. 46. ROSE O'HALLORAN.

SAN FRANCISCO, Sept. 20th, 1901.

U[3] Cygni.—The following observations of this Algol variable, discovered by Madam Ceraski on photographs taken at the Moscow Observatory, include but one minimum which occurred on June 14th. The normal size of the variable seems to be 9th magnitude, but on June 15th, 21st, 22nd, July 24th, August 1st, it rose to nearly 8.6 magnitude.

May 23rd, 10:00 P. M. It is midway between *a* and *f* of the comparison stars named in POPULAR ASTRONOMY No. 67 and accordingly is of 8.9 mag.
" 24th, 9:30 P. M. Ditto.
" 26th. Night not clear enough for comparison.

May 27th, 10:00 P. M. Nearly equal to *a* of 8.6 mag., but not as bright as *g* of 8.2 mag.
" 29th, 9:40 P. M. Equal to *f* of 9.2 magnitune.
" 30th, 9:30 P. M. Brighter than *f*, dimmer than *a*.
" 31st, 9:30 P. M. Ditto.
June 1st, 9:30 P. M. Ditto.
" 2nd, 9:30 P. M. Ditto.
" 3rd, 9:30 P. M. Not so near *a* in brightness, but brighter than *f*. Night not very clear.
" 4th, 8:55 P. M. Night clear. Still nearer to *f* than to *a*.
" 5th, 10:10 P. M. Equal to *f*. Night very clear.
" 6th, 9:00 P. M. Ditto
" 7th, 9:30 P. M. Ditto.
" 8th, 9:00 P. M. Ditto,
" 9th, 9;00 P. M. Ditto.
" 10th, 8:45 P. M. Brighter than *f*, not equal to *a*.
" 12th, 9:00 P. M. Ditto.
" 14th, 8:55 P. M. It is barely discernible, probably of 12th magnitude.
" 15th, 9:00 P. M. It is as bright as *a* but not as *g*.
" 21st, 9:15 P. M. Nearly as bright as *a*.
" 22nd, 9:15 P. M. Ditto.
" 23rd, 9:00 P. M. Only equal to *d* of 9.6 magnitude.
" 24th, 8:47 P. M. Equal to *f*.
" 25th, 8:50 P. M. Ditto.
" 26th, 9:00 P. M. Brighter than *f*.
" 27th, 8:40 P. M. Equal to *f*.
" 28th, 9:00 P. M. Ditto.
" 29th, 9:00 P. M. Slightly brighter than *f*.
" 30th, 9:00 P. M. Ditto.
July 2nd, 8:20 P. M. Brighter than *f*.
" 3rd, 8:40 P. M. Still slightly brighter than *f*.
" 4th, 10:40 P. M. Ditto.
" 5th, 8:50 P. M. Ditto.
" 7th, 9:00 P. M. Equal to *d*.
" 8th, 8:45 P. M. Brighter than f.
" 9th, 8:30 P. M. Equal to *f*.
" 10th, 8:30 P. M. Brighter than *f*.
" 13th, 9:00 P. M. Ditto.
" 18th, 8:50 P. M. Equal to *f*.
" 24th, 8:50 P. M. Nearly equal to *a*.
Aug. 1st, 8:30 P. M. Ditto.

ROSE O'HALLORAN.

SAN FRANCISCO, Sept. 20th, 1901.

Nova Persei.—Mr. F. E. Seagrave sends the following recent observations of the new star. The star *g* is DM 42°795 and *h* is DM 43°730:

Star.	Y.	M.	D.	75 Mer. T. h	m	J. Day	Comparison.
Nova Persei	1901	9	21	9	10	2415649	g ½ v 2½ h
"	"	"	22	9	15	50	g 1½ v 2½ h
"	"	"	"	9	40	"	g 1½ v 2½ h
"	"	"	23	8	50	51	g 1 v 2½ h
"	"	"	25	8	45	53	g 1½ v 2½ h
"	"	"	26	9	25	54	g 2 v 1½ h

Star.	Y.	M.	D.	75 Mer. T. h	m	J. Day	Comparison.
Nova Persei	1901	9	30	8	40	58	g 1½ v 1½ h
"	"	"	"	9	10	"	g 1½ v 1½ h
"	"	10	1	8	45	59	v = h
"	"	"	"	9	0	"	g 2 v ½ h
"	"	"	3	9	45	61	g 1½ v 1½ h
"	"	"	6	9	20	64	g 1 v 1½ h
"	"	"	"	9	45	"	g 1½ v 1 h
"	"	"	7	8	30	65	g 2 v ½ h
"	"	"	8	8	15	66	v = h
"	"	"	"	8	30	"	g 2 v ½ h

Nova is now white, with a slight greenish tinge, 6.9 to 7 magnitude.

GENERAL NOTES.

We are again on time, and the December number which closes the current volume will be mailed probably about the 24th of this month.

We have in hand for next month an excellent article from E. E. Barnard, of Yerkes Observatory, concerning his trip to Sumatra to observe the total solar eclipse of this year. It will be fully illustrated.

Our readers who are interested in the study and observations of the Sun will not fail to be attracted by the brief article by W. F. Denning of Bristol, England, on the motion of the Great Red Spot and other markings on Jupiter. Those who are specialists will find results for study; those who are not will readily see some of the lines of work that now occupy the attention of practical astronomers.

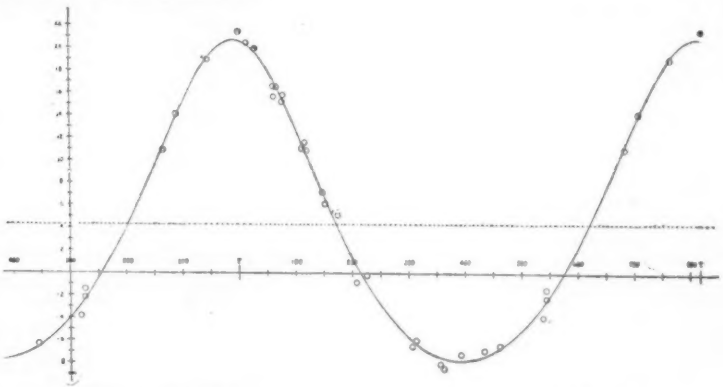
We want to call attention of the teachers of astronomy again to the great advantage of illustrative helps for efficient work in teaching astronomy, in elementary or advanced classes. Teachers of the present time, who have had only a little experience in science instruction of any kind, scarcely need to be reminded that laboratory work, of one kind or of another, is absolutely essential to class work that is time-saving, efficient, progressive and practically useful to meet the just demands on the modern teacher.

We have noticed with pleasure the results reached in our own astronomy classes in the use of the large photographs and star-maps (home-made) as means of illustrations in so many ways that the employment of them is almost of daily occurrence. We have used them so long and so much, that it would be next to impossible to do as well without them. About two or three years ago Professor C. L. Doolittle of the University of Pennsylvania, Director of Flower Observatory and author of Doolittle's Practical Astronomy, asked us to bind up 50 copies of the monthly star charts for a year, one of which we publish every month in POPULAR ASTRONOMY with the planet notes and tables for the month, for his classes. He seems to have found them useful, for he has just asked for another supply.

We have during the last three years furnished hundreds of copies of our large astronomical photographs for this same purpose to instructors of astronomy classes in universities, colleges and academies in different parts of the United States. Any instructor interested will be furnished promptly any further information desired.

Star Maps for Observational Astronomy.—We have just received a pamphlet, 7¼ by 8 inches in size, containing nine star charts. These maps appear to be projected well. They are printed in two colors, the names of the constellations and the letters designating the stars are blue, the reference lines, the star dots, the names of months and the titles are in black ink. The four brighter magnitudes of the stars only are represented on these maps, and the varying size of the dots is intended to distinguish the magnitudes without further symbol usually employed for that purpose. The titled cover, preface and middle wire stitching all add to the usefulness of the pamphlet. The printing is on highly finished, heavy paper, and it is very neatly done. For further information write to the author, Godwin D. Swazey, Professor of Astronomy in the University of Nebraska at Lincoln, Neb.

The Orbit of the Spectroscopic Binary η Pegasi.—The *Bulletin*, No. 5 of Lick Observatory contains the results of measurement of 29 photographs of the spectrum of this star, taken with the Mills spectroscope during the years 1896 to 1901. The velocities of the star in the line of sight vary from — 8 to + 21 kilometers. From all of the data Mr. Russell Tracy Crawford has computed the following elements:



CURVE OF THE VELOCITY IN THE LINE OF SIGHT OF η PEGASI.

$K = 14.20$ km	± 0.13 km	$T = 1898$ June 29.7 ± 8.1 days	
$e = 0.1548$	± 0.0106	$= 1900$ Sept. 25.7	
$\omega = 5°.605$	$\pm 3°.708$	$V_0 = +4.31$ km	± 0.10 km
$\mu = 0°.007681$ rad.	± 0.000020 rad.	$U = 818.0$ days	± 2.2 days
$= 0°.44009$	$\pm 0°.00117$	$a \sin i = 157{,}800{,}000$	

The accompanying curve represents the variation of the velocity in the line of sight. The small circles represent the observed velocities and their remarkably close agreement with the curve indicates how wonderfully accurate is the work which is done with the Lick apparatus.

The Leonid Meteors.—Although there is little prospect of any very marked shower from the Leonid swarm this year, it will be advisable for all who can to keep watch of the sky after midnight on Nov. 14 and 15. There will be no moonlight to interfere with observation and what meteors there may be, will be seen to the best advantage, provided of course that the weather permit.

It ought to be added, perhaps, that there are some who maintain that the great shower ought not to have been expected until this year, since according to their view the greatest shower at the last perihelion of the swarm was in 1867 and the period should be regarded as 34 instead of 33 years.

We enclose a copy of the chart, which has served so good a purpose in the past two years, for those who are interested in mapping the paths of the Leonids.

Bulletins from Lick Observatory.—An important step forward in the interest of astronomy has recently been taken by Lick Observatory, Mt. Hamilton, California, in the publication of its current work in the form of *bulletins*. These publications are in quarto form and consist of 8 to 10 or 12 pages as needed to present the themes in hand at the time of printing. Generally the articles are dated and signed by the person or persons directly responsible for them, and the matter is prepared by members of the staff of the Observatory. At the date of this writing (Oct. 20) we have received all the numbers in the series to No. 8. The contents of these Bulletins is excellent so far and we prize the publication as one of the best we receive.

The August Meteors.—The evening of the 13th of August was without Moon and with excellent conditions for the observation of shooting stars. Observations were made only in an off-hand way, as there was no anticipation of any sort of a display beyond the usual number observed at this time of year.

I commenced watching at about 10 P. M. and continued until midnight, when a heavy fog came in from the ocean and completely obscured all the stars. During the two hours fifty-four meteors were seen. Unfortunately the whole sky was not observed, the portion under observation was the southeast; the region extending from Capella to Jupiter, and some fifteen or twenty degrees beyond the zenith.

The principal radiant seemed to be the Square of Pegasus rather than the constellation of Perseus. The general direction pursued by the meteors was towards the southwest. Fully twenty appeared a few degrees south of the Square of Pegasus, and continued for from fifteen to twenty-five degrees in a direction towards Capricornus. These moved in nearly parallel paths. A few commenced directly in Perseus and pursued the same path; of these there were not more than five. Only two or three were seen to travel in a direction north or east of Perseus. The remainder appeared in different parts of the region observed, and did not seem to belong to any particular radiant.

In brightness the meteors ranged all the way from nearly as bright as Jupiter to as faint as could be seen. The brightest were those which moved slowly and only a short distance; probably coming towards us.

About twenty-five per cent of the meteors left trails; they were however only visible for a short time, rarely for more than a few seconds.

The color in most instances was a greenish yellow. This was particularly noticeable with the brighter ones. Those fainter seemed to be white.

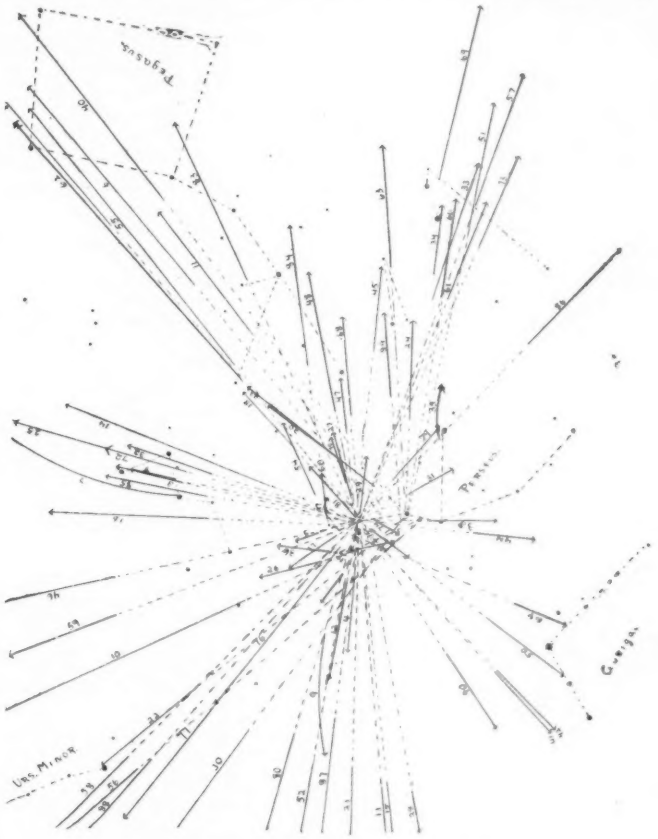
The meteors all moved with a rather rapid rate of speed. The brighter ones with some exceptions, seemed to move slower than those which were more faint. The greatest display was from ten o'clock until eleven, forty-two meteors being observed during that time. From eleven to half past there was a great diminution in the number seen. After half past eleven the display seemed to commence again, and continued until twelve when the fog came in and rendered further observations impossible.

The observing as I have stated was done in a very off-hand way. No times were recorded, nor were any plottings made of the trails. No subsequent observations were made as the fog continued for nearly a week.

WALTER M. MITCHELL, (Univ. of Penna.)

SEAL HARBOR, MT. DESERT, Maine,
August 20, 1901.

"The August Meteors."—The weather here was very disappointing for observation of the Aquarids and Perseids. It was totally cloudy during the



THE PERSEID METEORS, AUGUST 1901.

week of the 25th, so nothing could be observed. During the Perseid shower it was cloudy from the 5th to the 11th. The 11th was clear till 9:00. The 13th was clear until 1:30. On August 11th 9 Perseids were seen. On the 13th there were 79. The radiants were γ Persei, η Persei, α Persei and one radiant near γ Camelopardali. The majority shot from γ Persei.

July 23	8	Perseids from	α	Persei
" 23	9	" "	β	"
Aug. 11	9	" "	Perseus	
" 13	79	" "	"	
" 16	4	" "	"	
Miscel.	6	" "	"	

Total 115 Perseids.

There were	3	of 5th	magnitude	
" "	10	" 4th	"	
" "	11	" 3rd	"	
" "	19	" 2nd	"	
" "	17	" 1st	"	
" "	33	" 0	"	(bright as Capella)
" "	18	" −1	"	(" " Sirius)
" "	6	" −2	"	(" " Jupiter)
" "	2	" −3	"	(" " Venus)

METEORS MAPPED.

No.	Date.	Time.	Magn.	Color.	No.	Date.	Time.	Magn.	Col.
1	Aug. 5	——	0	W	46	Aug. 13	10:35	2.5	W
2	11	8:40	0	W	47	"	10:48	5	B
3	"	8:50	2	G	48	"	11:30	0	R
4	"	8:55	2	W	49	"	11:52	4	W
5	"	9:06	−2	W	50	"	11:53	0	R
6	"	9:11	−1	B	51	"	11:55	0	R
7	"	9:28	2.5	W	52	"	11:57	1	W
8	"	9:36	2.5	W	53	"	12:00	−1	R
9	"	9:50	−2	W	54	"	12:05	3	W
10	13	8:28	−3	Or	55	"	12:06	2	W
11	"	8:37	0.5	R	56	"	12:08	−1	R
12	"	8:48	2	W	57	"	12:13	0	R
13	"	8:49	4	W	58	"	12:14	4	W
14	"	8:50	−1	R	59	"	12:21	3	W
15	"	8:55	0	R	60	"	12:22	0	R
16	"	8:56	−1	R	61	"	12:26	−2	R
17	"	9:07	3	W	62	"	12:27	2	W
18	"	9:07	1	W	63	"	12:28	−1	R
19	"	9:14	3	R	64	"	12:30	0	R
20	"	9:16	−1	R	65	"	12:34	0	R
21	"	9:17	0	W	66	"	12:36	2	W
22	"	9:22	1	W	67	"	12:37	1	W
23	"	9:22	1	R	68	"	12:38	3	W
24	"	9:23	0	W	69	"	12:44	2	W
25	"	9:27	−1	R	70	"	12:46	0	R
26	"	9:31	1	R	71	"	12:47	3	W
27	"	9:39	1	R	72	"	12:47	4	W
28	"	9:39	5	W	73	"	12:47	−1	R
29	"	9:47	−1	R	74	"	12:48	3	W
30	"	9:48	−1	R	75	"	12:54	3	B
31	"	9:48	4	B	76	"	12:54	2	W
32	"	9:58	0	W	77	"	12:54	2	W
33	"	10:03	1	W	78	"	12:57	−1	R
34	"	10:08	0	W	79	"	1:02	3	W
35	"	10:09	2	B	80	"	1:02	−1	R
36	"	10:11	1	W	81	"	1:04	0	R
37	"	10:12	−2	R	82	"	1:05	0	R
38	"	10:13	1	B	83	"	1:14	0	R
39	"	10:15	0	R	84	"	1:15	0	R
40	"	10:20	0	R	85	"	1:16	0	R
41	"	10:22	5	W	86	"	1:17	−1	R
42	"	10:28	0	R	87	"	——	0	R
43	"	10:29	0	R	88	"	——	0	R
44	"	10:30	4	W	89	"	——	0	R
45	"	10:31	−3	R	90	"	——	0	R

There were more bright ones than faint ones. The average was 1 in 2¾ minutes. The color of the meteor itself was usually red or orange, and the color of the trail white, green or yellow. The shower was quite brilliant as compared with last year. The majority rivaled Capella, and several Jupiter and Venus.

ROBERT M. DOLE.

OGUNQUIT, Me.

Meteors During July and August.—Only eight nights have been free from clouds here so that the shooting stars could be observed. With two exceptions, the observations lasted about an hour. Two hundred and ninety have been observed up to the 16th.

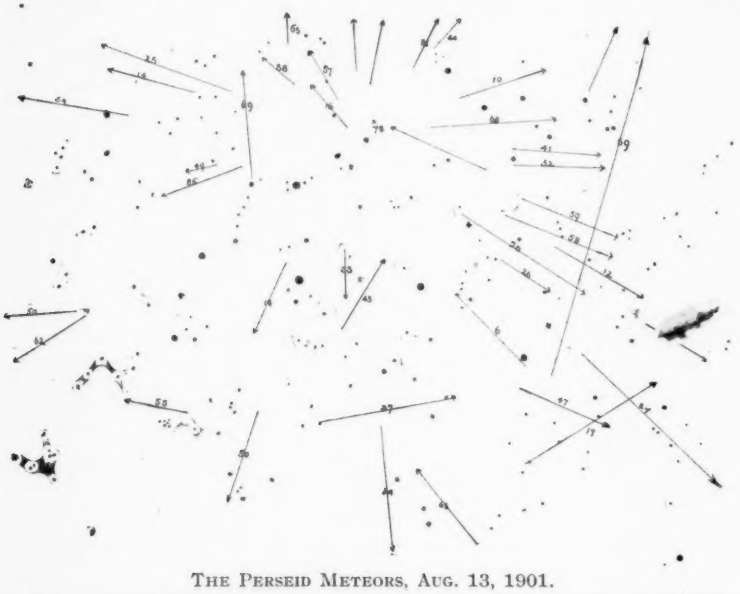
From	Radiants	in Cassiopeia	17
"	"	" Pegasus	34 (η and γ)
"	"	" Cygnus	49
"	"	" Aquarius	13 (δ)
"	"	" Lyra	7
"	"	" Draco	40 (three radiants)
"	"	" Perseus	114 (α, β, γ, η)
"	"	" Urs. Min.	3
"	"	" Urs. Maj.	7
"	"	" Auriga	6 (η)
		Total	290
		Miscellaneous shooting stars	23
		Grand total	313

ROBERT M. DOLE.

The Oldest Observatory in Europe.—According to the *Central Zeitung für Optik and Mechanik*, it seems possible that the Vatican may claim to have possessed the first European Observatory. In 1582, a tower was built at the Vatican for observing the heavens, and, according to Crescenzi, who wrote an important work on astronomy, Pope Gregory XIII, was the person to whom the credit is due of having built it. Probably the work was undertaken in connection with the reform of the calendar. This fact is but little known, and 1888 is usually supposed to be the date of founding the Observatory. A short time ago we drew attention to the fact that a rich American had offered to present the Vatican with a giant telescope, and it is said the instrument will be even larger than that shown at the Paris exhibition. The *Central Zeitung* states that a large number of the instruments at the Vatican, including the fine telescope by Dolland, were presented by the Cardinal Zelada over one hundred years ago. The Observatory has had great changes in fortune. Under Philip Gili, who had charge of it for thirty years in the early part of the last century, its reputation stood very high. Gili died in 1821. The instruments were then scattered, and the Observatory remained empty and neglected. Pope Leo XIII, on the celebration of his jubilee as priest, in 1888, collected the instruments again, and since then the Observatory has entered upon a new period of prosperity. It is now furnished with the most modern apparatus and will bear comparison with any other European Observatory.—*British Journal of Photography, No. 2159.*

Observations of the Perseids, 1901.—The Perseids were observed here on the nights of July 28th and August 7th, 8th and 9th. On July 28th, from $13^h\ 58^m$ to $16^h\ 10^m$, 23 meteors in all were seen; 8 of these were Perseids and 5 δ Aquarids; 5 Perseids were plotted on a map and gave the following radiant: α 9°; δ 55° 10′. Several of the these were bright and had the red tinge generally seen in members of this stream. One δ Aquarid, which was equal to

Jupiter in brightness, burst or rather threw off a fragment about the middle of its course, both fragments continuing their respective paths. No more favorable nights came until August 7th, which was mostly clear. On this night from 11^h 30^m to 13^h 30^m, 13 were seen. About one-half came from the Perseid radiant but not enough were plotted to give its position. August 8th was very clear and watch was kept from 11^h 50^m to 15^h 50^m with one or two intervals. 32 meteors were seen for the most part from Perseus. These were mostly faint. The radiant as deduced from 7 well observed meteors was α 33°, δ 55° 10′. On Aug. 9th 90 meteors in all, of which 55 were Perseids, were observed from 10^a 30^m to 16^h. However, there was an interval of about one hour from 11^h to 12^h. About half



THE PERSEID METEORS, AUG. 13, 1901.

of the total are plotted on the accompanying chart. The radiant deduced from all meteors plotted was α 41° 30′ δ 56° 10′. The Perseids were mostly faint and swift. If bright they were red or yellow leaving trains. Two minor radiants were located at α 43° δ + 39° and α 31° δ + 32° 45′. Each of these was determined by 3 meteors, the second also by 2 on the 8th. The 9th was very clear. The tabulated data for each meteor is omitted on account of its great length. The time used was mean local.

CHARLES P. OLIVIER.

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Charlottesville, Va., Aug. 13, 1901